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July 31, 2012

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RE: Revised Vapor Extraction Pilot Test Work Plan and Quality Assurance Project Plan
UniFirst Property
Wells G&H Superfund Site, Woburn, Massachusetts

Dear Joe,

The attached *Revised Vapor Extraction Pilot Test Work Plan* (Work Plan) has been prepared on behalf of UniFirst Corporation (UniFirst) by Dr. B.H. Kueper and The Johnson Company, Inc. for submittal to the United States Environmental Protection Agency (USEPA). This Revised Work Plan presents the technical justification, objectives, and implementation procedures for proposed pilot testing of vapor extraction at the UniFirst Property located at 15 Olympia Avenue in Woburn, Massachusetts (the Property). The purpose of the pilot testing is to collect data for purposes of designing a full-scale vapor extraction system. Some data pertinent to preparation of an ISCO work plan will be collected during the sampling program for the vapor extraction pilot test; specifically bedrock samples for natural oxidant demand (NOD) will be collected. Per USEPA's direction at the June 20, 2012 meeting, UniFirst will defer preparation of a work plan for implementation of ISCO until after the vapor extraction pilot test has been completed.

This Revised Work Plan addresses comments provided by the USEPA in a letter dated February 10, 2012 (February Comment Letter) regarding the *Vapor Extraction Pilot Test Work Plan* submitted to the USEPA on April 29, 2011 and reflects subsequent discussion between USEPA and UniFirst at the June 20, 2012 meeting. A Quality Assurance Project Plan (QAPP) for the pilot testing is provided as Attachment 1 to this Revised Work Plan.

Field planning for the pilot testing will be initiated following USEPA approval of this Revised Work Plan and QAPP. UniFirst anticipates that the proposed pilot testing can be initiated approximately four weeks following USEPA approval. The proposed timeline for implementation of the pilot test and subsequent pilot test report preparation is provided in Form D of the QAPP.

Please contact me if you have any questions or would like to schedule a meeting with your team to discuss the contents of this Revised Work Plan and QAPP.

Sincerely,



Timothy Cosgrave
UniFirst Project Coordinator

cc:

Cindy Lewis, US EPA
Joe Coyne, MassDEP
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REVISED VAPOR EXTRACTION PILOT TEST WORK PLAN

**UniFirst Property
Wells G&H Superfund Site
Woburn, Massachusetts**

July 2012

Submitted To:

**United States Environmental Protection Agency
Region 1
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PARTNERS FOR SMART THINKING
AND CREATIVE STRATEGIES

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1.0 INTRODUCTION

This Revised Vapor Extraction Pilot Test Work Plan (Work Plan) has been prepared for the Property located at 15 Olympia Avenue in Woburn, Massachusetts (the Property). This Revised Work Plan has been prepared on behalf of UniFirst Corporation (UniFirst) by Dr. B.H. Kueper and The Johnson Company, Inc. (The Johnson Company) for submittal to the United States Environmental Protection Agency (USEPA). This Revised Work Plan addresses comments provided by the USEPA in a letter dated February 10, 2012 (February Comment Letter) regarding the Vapor Extraction Pilot Test Work Plan submitted to the USEPA on April 29, 2011 and reflects subsequent discussion between USEPA and UniFirst during a June 20, 2012 meeting.

This Work Plan presents technical justification, objectives, and implementation procedures for proposed pilot testing of vapor extraction as a preliminary step in the design of a full-scale system. The purpose of the pilot testing is to collect data for purposes of tailoring and designing a full-scale vapor extraction system. This Work Plan also summarizes previous on-Property characterization activities and data, unconsolidated deposits geology and hydrogeology, and the system elements and monitoring plan for the proposed pilot testing.

This Work Plan is divided into seven sections.

- Section 1 provides an introduction.
- Section 2 provides a regulatory overview.
- Section 3 presents background information and next steps rationale, including the specific objectives of the vapor extraction pilot test.
- Section 4 presents the proposed scope of work for vapor extraction pilot testing, including point installation, performance monitoring, and data evaluation.
- Section 5 describes post-implementation reporting.
- Section 6 presents a proposed implementation schedule.
- Section 7 includes references cited.

A Quality Assurance Project Plan (QAPP) for the pilot testing is provided as Attachment 1.

2.0 REGULATORY OVERVIEW

The September 14, 1989 ROD for the Source Area properties (OU-1) established the following remedial objectives for soil (USEPA, 1989):

- Prevent public contact with contaminated soil above the cleanup levels;
- Stop the leaching of soil contaminants to the ground water; and
- Protect the natural resources at the Site from further degradation.

Public contact with contaminated soil is prevented by the current on-Property building and the paved Property surface. Groundwater remediation using a 190-foot deep bedrock recovery well (UC22) installed on the UniFirst property has been operating since September 1992. The effectiveness of this remedy has been documented in numerous monthly, quarterly, annual, and other reports submitted to USEPA evaluating the results of groundwater monitoring and sampling conducted over the course of 19 years of remedy operation.

Current volatile organic compound (VOC) concentrations in unconsolidated deposits and bedrock groundwater beneath the UniFirst property are significantly lower than historical concentrations, reflecting 19 years of groundwater remedy operation. Tetrachloroethene (PCE) concentrations in groundwater in the eastern portion of the Property, however, continue to exceed the concentration of 85 µg/L at which volatilization of VOCs from groundwater will continue to recontaminate soils to levels above the ROD clean-up goal, as presented in the *Summary of Unconsolidated-Deposits Investigations at the UniFirst Property, Woburn, Massachusetts* report (Unconsolidated Deposits Report) (Applied Groundwater Research, Ltd. and Environmental Project Control, Inc., 1994). As a result, overlying soils in those areas will continue to be impacted above the ROD-specified goal for soil (i.e., 37 micrograms per kilogram [µg/kg] for PCE in soil) by the upward migration of VOC vapors from contaminated groundwater.

USEPA's May 14, 2009 draft *Comments on OU-1 UniFirst Remedial Action Reports* requested that UniFirst "collect soil and soil gas data and any other appropriate data at the Property including under the foundation, and propose a plan for implementing the soil

remedy...” (p. 13). Extensive soil data have been collected historically beneath and outside the building footprint. Those data are summarized in reports previously submitted to USEPA, including the Unconsolidated Deposits Report. Collection of additional soil and soil gas data, including screening for the presence of dense nonaqueous phase liquid (DNAPL), is proposed as part of this Work Plan.

In spring 2010, UniFirst and W.R. Grace & Co. – Conn. (Grace) installed monitoring wells downgradient of their properties pursuant to the USEPA-approved *Vapor Intrusion Assessment Work Plan, Revision 1* (GeoTrans, 2009). In summer 2010 and spring 2011, UniFirst and Grace collected groundwater samples from these new monitoring wells and from existing wells on their properties. In April 2010 and February 2011, UniFirst collected sub-slab soil gas and indoor air samples from the on-Property building. In winter and spring 2011, UniFirst and Grace collected sub-slab soil gas and indoor air samples from some off-property buildings.

USEPA conducted a human health risk assessment based on the data collected in 2010 and 2011 and issued an *Addendum to the Third Five-Year Review for the Wells G&H Superfund Site* in April 2012 (April 2012 Addendum). In the April 2012 Addendum, USEPA concluded that the vapor intrusion pathway is not likely to pose unacceptable current or future indoor air risk at the UniFirst on-Property building under the current commercial use scenario. USEPA noted a potential unacceptable future indoor air risk associated with the vapor intrusion pathway at the on-Property building in the unlikely event that it were to be used for residential purposes in the future. PCE and trichloroethene (TCE) were not identified at significant concentrations in any indoor air samples; however, USEPA noted that the presence of elevated concentrations of PCE and TCE in sub-slab soil gas beneath the on-Property building indicates a potential for a future vapor intrusion pathway to indoor air if building conditions or property usage were to change.

Based on historical and recent sampling results, and to respond to USEPA’s comments, UniFirst is proposing at this time to proceed with a multi-point vapor extraction pilot test at locations both under and outside the on-Property building foundation. The purpose of the pilot

test is to collect data for purposes of tailoring and designing a full-scale vapor extraction system. The existing soil and soil vapor data are sufficient to design and implement a vapor extraction pilot test. The historical data, together with the new data to be collected as described in this Work Plan, will be used to design the full-scale system.

Relevant Property operational information, hydrogeology, and analytical data that provide the technical foundation for the proposed vapor extraction pilot test are summarized in the following section. The objective and proposed scope of work for installation, operation, and performance monitoring of the proposed pilot test are presented in the subsequent section.

3.0 BACKGROUND AND NEXT STEPS RATIONALE

Environmental investigations on the UniFirst property began in 1983 and have continued through to the present. On-Property investigations have included soil boring drilling, bedrock coring, monitoring well installation, test pit excavation, soil and groundwater sample collection and analysis, hydraulic testing, and soil vapor testing. Site operational, hydrogeology, and characterization and analytical data relevant to design of the proposed pilot test are summarized in the sections below and in the referenced reports, tables, and figures.

3.1 PROPERTY CONDITIONS

The Property is approximately 3 acres in size (Figure 1) and was undeveloped prior to 1965. Building A was constructed in November 1965, Building B was constructed in 1966, and Building C was constructed in 1978 (Figure 2). In the late 1970s, the loading dock at the east end of the Property was upgraded and enclosed. The current single story building encloses approximately 57,000 square feet (ft²). All portions of the current building are slab-on-grade construction with concrete block walls. Since 1989, most of the building has been leased to Extra Space Storage, formerly known as Woburn Storage Depot. The leased space has been converted into storage units that are subleased individually to customers, and a small administration office located in the south central area of the building (Figure 2).

The chronology of building construction and operating history at the Property has been well documented in reports previously submitted to USEPA, including the letter from Harvard

Project Services LLC (HPS) to Joseph LeMay dated January 8, 2010 (HPS, 2010a). The Property was acquired by B&S Realty Trust and leased to Interstate Uniform Service Corporation (IUS)¹ in 1965. Figure 3 illustrates approximate locations of former IUS operations features. Buildings A and C were historically used for garment storage or office space only; neither laundry operations nor storage or use of chemicals and equipment associated with those operations were conducted in Buildings A or C (HPS, 2010a). For a short time, between 1967 and 1969, IUS operated a “white shirt laundry” in Building B. This operation consisted of one dry cleaning machine and several conventional washing machines located on the west side of a north-south oriented concrete wall that remains today; the approximate locations of the washing machines, dry cleaning machine, and drain trench or “gutter” are shown on Figure 3. The washing machines were located on a washroom trench that ultimately connected to the sanitary sewer. Neither the data nor the record of historical operations indicate that this former trench or “gutter” inside the on-Property building was an entry point for DNAPL (UniFirst, 2012). PCE concentrations detected in soil vapor in the area of the former trench are consistent with volatilization of dissolved PCE from the plume of impacted groundwater that originates in the vicinity of UC8 and extends beneath the on-Property building in this area (as discussed further in Section 3.4 of this Work Plan).

PCE was stored in the on-Property building between 1966 and 1968, and between 1977 and 1982. Approximately five to six 55-gallon drums of PCE were utilized each year during the 1966 to 1968 time period. PCE was stored in a 5,000 gallon aboveground storage tank located at the east end of Building B (Figure 3) during the 1977 to 1982 time period, immediately following which the tank was removed. The fill pipe for the tank was located outside the building, within the former at-grade loading dock at the east end of the building. The tank was used principally to store PCE for occasional distribution to IUS branch operations. Small quantities of less than 50 gallons at a time were reportedly pumped off for distribution to other locations. One load of 1,1,1-trichloroethane (1,1,1-TCA) also was reportedly delivered to the

¹ IUS changed its corporate name to UniFirst Corporation in 1986 and took title to the Property that same year.

tank. In late 1979, a spill of approximately 100 gallons of PCE occurred inside Building B; the spill was reportedly noticed and cleaned up within an hour. No floor drains or weep holes existed in this portion of the building.

Extensive unconsolidated deposits investigations were undertaken at the Property in the 1980s and 1990s. These included: logging and soil sampling from 32 borings and 13 test pits; installation of 14 soil vapor probes, 7 vapor monitoring wells, and 21 groundwater monitoring wells; chemical analysis of 140 unconsolidated deposit soil samples; characterization of approximately 60 soil samples for grain size, moisture content, organic carbon content, and other physical properties; petroleum hydrocarbon characterization of 29 unconsolidated deposit samples and bituminous concrete pavement (asphalt) samples; and chemical analysis of approximately 30 soil vapor samples. The Unconsolidated Deposits Report lists and summarizes the results of six prior unconsolidated deposits-specific reports, and Figure 3-3 of that report shows the extent of investigations conducted on the east end of the Property, including efforts to identify any evidence of high VOC concentrations in soil or other indications of residual DNAPL within former operations areas. Section 4.0 of the Unconsolidated Deposits Report presented a conceptual model based on the extensive unconsolidated deposits investigations. These investigations were completed years after cessation of operations on the Property that could potentially have affected soil and groundwater, and the operating conceptual model remains relevant and applicable and the characterization data robust.

At USEPA's direction, additional data were collected in 2010 and 2011 to monitor VOC concentrations in groundwater samples from wells screened in unconsolidated deposits (HPS, 2010b; GeoTrans, 2010; UniFirst, 2011; Tetra Tech GEO and JG Environmental, Inc., 2011) and in sub-slab vapor beneath the on-Property building (The Johnson Company, 2010, 2011). These data provide further support for the operating conceptual model.

3.2 UNCONSOLIDATED DEPOSITS GEOLOGY

The on-Property building is underlain by unconsolidated soils that consist of Pleistocene-age till and overlying native and non-native fill. The total thickness of unconsolidated deposits

varies considerably across the Property. Beneath the northeast portion of the building, less than five feet of unconsolidated deposits are present above the underlying bedrock. This bedrock surface drops off to the west, and the unconsolidated deposits thicken to approximately 55 to 65 feet beneath the western portion of the building. Fill at the Property is generally described as a tan to brown sand and gravel with a minor silt-sized fraction. Beneath the eastern portion of the building, the till is referred to as an “ablation till” and consists of a poorly-sorted mixture of silt, sand, and gravel with boulders common. An approximately 1.5-foot thick “lodgement till” has been logged beneath the ablation till and above the bedrock at some locations. The lodgement till is dense and has a coarse to fine sand and gravel grain size distribution with little silt. Additional geologic and hydrogeologic details for the unconsolidated deposits underlying the on-Property building were presented in the Unconsolidated Deposits Report.

3.3 UNCONSOLIDATED DEPOSITS HYDROGEOLOGY

Ongoing groundwater pumping from extraction well UC22 has lowered the groundwater table across the Property. Unconsolidated deposits water levels on the eastern portion of the Property are approximately five to ten feet lower compared to non-pumping conditions. Certain portions of the unconsolidated deposits on the eastern end of the Property remain unsaturated throughout most of the year as a result of pumping. Specifically, unconsolidated deposits wells UC34, UC35, and UC36 are typically dry, and unconsolidated deposits wells UC32 and UC33 are sometimes dry. Water level data collected in April 2009 (seasonally high water table) and September 2010 (seasonally low water table) for on-Property wells are presented in Table 1. It is estimated that unconsolidated deposits are unsaturated through their full thickness (approximately 7 to 8 feet) throughout the year in the eastern portion of the Property where VOC impact to unconsolidated deposits is highest. Recent water level data indicate an approximately 9 to 16 foot unsaturated thickness of unconsolidated deposits under the western portion of and southwest of the on-Property building.

Air phase permeability of the unsaturated unconsolidated deposits has been estimated at 5×10^{-12} centimeters squared (cm^2) to $3 \times 10^{-8} \text{ cm}^2$ (Applied Groundwater Research, Ltd. and Environmental Project Control, Inc., 1994).

3.4 VOCS IN UNCONSOLIDATED DEPOSITS SOIL AND GROUNDWATER

Environmental investigations at the Property identified two areas where chlorinated solvents were apparently released to the ground surface, termed in the Unconsolidated Deposits Report as the waste-oil contamination area and a “release area” to the south of the current loading dock. Focused source area characterizations showed that within the unconsolidated deposits these two release areas were limited in lateral extent, and that concentrations detected in soil samples implied the presence of residual DNAPL in small discontinuous zones within each area. Historical unconsolidated deposits sample data, including samples collected from underneath Building B, are summarized in Table 2.

The focused source area characterization included groundwater sampling, soil vapor sampling, soil sampling, and test pit observations; sampling locations are shown on Figure 4. PCE concentrations up to 2,500,000 µg/kg were reported in soil samples. Lower PCE concentrations (not indicative of DNAPL presence) were observed at shallow depths below the Building B foundation, near the location of the former PCE tank and “gutter” trench, at borings UC35 (8,900 µg/kg, interval 0.5 to 2 feet) and UC34 (4,400 µg/kg, interval 3 to 4.5 feet). 1,1,1-TCA concentrations up to 12,000 µg/kg also were reported (1,1,1-TCA concentrations may have been higher in some samples where reporting limits were elevated due to high PCE concentrations). Neither the data nor the record of historical operations indicate that the former trench or “gutter” inside the on-Property building was an entry point for DNAPL (UniFirst, 2012). An area of impacted soil with VOC concentrations greater than 500 µg/kg was identified near the former loading dock by the source area characterization and is shown on Figure 4.

PCE DNAPL is believed to have migrated predominantly downward with limited lateral spreading through the relatively thin unconsolidated deposits beneath the release areas to the underlying bedrock. A substantial portion of the contaminated soils was removed during excavation of an influent line trench between 1992 and 1994. The results of the soil vapor survey and soil sampling demonstrated that the VOC impact to unconsolidated deposits was limited to the east end of the Property, and that PCE was the principal contaminant, with some TCA also present in the area south of the loading dock. The characterization data also identified

a zone of low to moderate PCE concentrations in soil vapor extending southwestward from the loading dock at the east end of the Property, consistent with upward vapor migration from shallow groundwater (Figure 5).

Sub-slab vapor samples were collected in both April 2010 and February 2011 at 15 locations in the on-Property building and analyzed for various constituents, including VOCs and air-phase petroleum hydrocarbons (APH). A report of work performed and data collected during the April 2010 sampling event was submitted to USEPA in June 2010 (The Johnson Company, 2010). A report of work performed and data collected by ARCADIS U.S., Inc. (ARCADIS) during the February 2011 sampling event was submitted to the USEPA in April 2011 (The Johnson Company, 2011). A human health risk assessment prepared by ARCADIS based upon validated indoor air data from both April 2010 and February 2011 also was submitted to the USEPA in April 2011 (The Johnson Company, 2011).

Chlorinated VOC concentrations in sub-slab vapor samples from April 2010 and February 2011 are presented in Tables 3 and 4 and shown on Figures 6 and 7, respectively. The 2010 and 2011 sub-slab vapor sampling data showed elevated concentrations of PCE and, to a lesser extent, 1,1,1-TCA in sub-slab vapor beneath portions of the building. Consistent with historical operations at the Property, there was no indication of significant APH impact to sub-slab vapor; low detections of APH constituents at some sampling locations are unlikely to be indicative of significant sub-slab petroleum material in these areas. Sub-slab concentrations of chlorinated VOCs were generally highest under the center and eastern portion of Building B (e.g., locations SV-05, SV-06, SV-07, SV-10, SV-11, SV-12 and SV-13; Figures 6 and 7). These results generally mirror VOC concentrations in groundwater and are consistent with prior soil sampling results.

Concentrations of PCE in sub-slab vapor samples collected in April 2010 ranged from 68 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) to 420,000 $\mu\text{g}/\text{m}^3$. Concentrations of PCE in sub-slab vapor samples collected in February 2011 were consistent with the April 2010 data (generally lower

but within a factor of 3), ranging from 38.6 $\mu\text{g}/\text{m}^3$ to 452,000 $\mu\text{g}/\text{m}^3$. Concentrations of 1,1,1-TCA in sub-slab vapor samples collected in April 2010 ranged from 0.234 $\mu\text{g}/\text{m}^3$ to 1440 $\mu\text{g}/\text{m}^3$, and were highest at locations SV-05, SV-06, and SV-12 along the southern portion of the building. 1,1,1-TCA concentrations in February 2011 sub-slab samples ranged from 0.229 $\mu\text{g}/\text{m}^3$ to 2090 $\mu\text{g}/\text{m}^3$, consistent with the April 2010 data (generally lower but within a factor of 4).

VOC concentrations in groundwater samples collected in April 2011 from shallow on-Property wells are summarized in Table 5. Consistent with historic data, PCE remains the primary VOC detected in on-Property groundwater. Figure 8 presents PCE concentrations for April 2010 and February 2011 sub-slab vapor samples, and also for groundwater samples collected in April 2011 from on-Property water table wells. 2011 PCE concentrations in unconsolidated deposits groundwater on the Property are significantly lower than historical concentrations, reflecting 19 years of UC22 operation. Ongoing groundwater extraction from well UC22 has lowered the groundwater table across the Property, and recharge of clean water to unconsolidated deposits has significantly reduced VOC concentrations in shallow groundwater since 1993 (Kueper and Guswa, 2010).

The area of highest impact to shallow groundwater remains the vicinity of shallow bedrock monitoring well UC8 (PCE concentration in groundwater of 87,000 micrograms per liter [$\mu\text{g}/\text{L}$] in July 2010), the only location where DNAPL has been observed historically (identified as Area 1 on Figure 8). In a February 1, 2012 letter to USEPA (UniFirst, 2012) and at the June 20, 2012 meeting with USEPA, UniFirst proposed to implement *in situ* chemical oxidation (ISCO) as a targeted strategy to reduce source area mass in bedrock at and in the vicinity of UC8. UniFirst proposes a combined and complementary implementation of ISCO and vapor extraction technologies at the Property to reduce source area mass and address potential vapor intrusion concerns, considered as a whole. Per USEPA's direction at the June 20, 2012 meeting, UniFirst will defer preparation of a work plan for implementation of ISCO until after the vapor extraction pilot test has been completed.

Although some lateral migration of vapors beneath the slab from the former release area near UC8 may be occurring, impacts to sub-slab vapor observed in 2010 and 2011 are consistent with the most recent groundwater data collected from water table wells across the Property. A zone of low to moderate PCE concentrations in sub-slab soil vapor continues to extend southwestward beneath the on-Property building from the east end of the Property (overlying the area identified as Area 3 on Figure 8). This observation is consistent with soil vapor data and the location and route of soil vapor impact presented in the Unconsolidated Deposits Report (see Figure 5). Consistent with the characterization data and interpretation presented in that report, observed PCE concentrations in sub-slab vapor samples collected in 2010 and 2011 outside the soil source area (identified as Area 2 on Figure 8) are consistent with volatilization of PCE from underlying groundwater. For example, using a dimensionless Henry's law coefficient of 0.468 (TRRP, 2006 value of 0.765 at 20 degrees Celsius adjusted to represent a typical New England groundwater temperature of 10 degrees Celsius), a PCE concentration in groundwater of approximately 54 µg/L would generate a theoretical maximum equilibrium soil vapor concentration of 25,100 µg/m³ PCE, equivalent to that measured at SV-09 in April 2010. At monitoring well UC29S, approximately 50 feet upgradient of SV-09, the PCE concentration in groundwater was 160 µg/L in July 2010. As projected at the time UC22 began operation, therefore, groundwater extraction and treatment have reduced PCE concentrations in groundwater on the Property, but DNAPL in bedrock continues to contribute a source of PCE, resulting in elevated concentrations in groundwater near the historical source areas; those groundwater concentrations, in turn, generate PCE concentrations in soil vapor sufficiently high to re-contaminate soil to concentrations above the ROD soil clean-up level.

3.5 NEXT STEP RATIONALE

As discussed in Section 2.0, USEPA conducted a human health risk assessment based on the indoor air data collected in 2010 and 2011 and summarized the results in the April 2012 Addendum. USEPA concluded that the vapor intrusion pathway is not likely to pose unacceptable current or future indoor air risk at the UniFirst on-Property building under the current commercial use scenario. PCE and TCE were not identified at significant concentrations

in any indoor air samples; however, USEPA noted that the presence of elevated concentrations of PCE and TCE in sub-slab soil gas beneath the building indicates a potential for a future vapor intrusion pathway to indoor air if building conditions or property usage were to change.

Areas of high, moderate, and relatively low VOC impact to on-Property unconsolidated deposits (identified as Areas 1, 2, and 3, respectively, on Figure 8) have been well documented through extensive historic sampling and testing at the Property, and are supported by recent sub-slab vapor and shallow groundwater data. Pilot testing will provide additional data necessary to confirm the target area and refine parameters for a full-scale system design.

4.0 SCOPE OF WORK

The April 1991 Explanation of Significant Differences (ESD) identifies vapor extraction as the preferred remedy for soils, and the Scope of Work calls for pilot testing prior to full-scale design. UniFirst is proposing to proceed with pilot testing at locations under and northeast of the on-Property building to collect data for purposes of tailoring and designing a full-scale vapor extraction system.

Pilot testing will be conducted at locations within the soil area with the highest concentrations of VOCs under and near the building, based on historical soil sampling data, historical operational features and information, and recent sub-slab vapor and shallow groundwater sampling data. The vapor extraction pilot test also will include vapor recovery points installed under the building slab where VOC impacts to soil vapor were observed at concentrations of potential concern. The purpose and scope of this Work Plan are limited to collecting pilot-scale data necessary to complete a full-scale design, including final extraction points, extraction rates, treatment system requirements, monitoring procedures, and technically practicable long-term goals.

4.1 OBJECTIVES

The objectives of the pilot test are to:

- collect data to estimate radius of influence (ROI) and soil vapor flow velocities (i.e., the *ex situ* velocity of soil vapor extracted from the test point) at different applied vacuums for estimating well field layout for full-scale design;
- identify potential interference by subsurface structures that may influence extraction point ROI;
- assess possible anisotropy in extraction point ROI;
- evaluate the potential effect of vacuum-induced groundwater mounding;
- determine the expected range of VOC concentrations in extracted soil vapor for estimating potential VOC mass removal rates for full-scale design; and
- determine the expected VOC constituent composition in extracted soil vapor to support selection of an appropriate and cost-effective technology for treatment of extracted soil vapor in the full-scale design (e.g., granular activated carbon [GAC], thermal oxidation, or catalytic oxidation).

The scope of work for the pilot test will consist of the following tasks: vapor extraction point installation, observation point installation, performance monitoring, data evaluation, and reporting. Soil sampling for laboratory analysis and DNAPL screening via hydrophobic dye testing will be performed during installation of the pilot test points to provide supplemental characterization of soil conditions. A description of these tasks is included in the following sections. Additional details of vapor extraction and observation point design are presented in Appendix A.

The pilot test system will consist of the following elements:

- 5 pilot test vapor extraction points (SVE-1 through SVE-5);
- 31 new ROI observation points (SVM-1 through SVM-31);
- up to 5 existing groundwater monitoring wells and 6 existing sub-slab vapor sampling points targeted as additional observation points;
- a mobile blower system with vapor-liquid separator and ports for monitoring vacuum, *ex situ* vapor flow velocity, temperature, and total VOC concentration;
- GAC for treating extracted vapors; and
- 55-gallon drums, as needed, for condensate generated by the vapor-liquid separator.

The actual specifications for the equipment skid (including vapor treatment unit) will be determined based on selection and availability of qualified equipment vendors. A minimum blower capacity of 80 cubic feet per minute at a vacuum of 93 inches of water ("H₂O) will be specified to accommodate a range of operating conditions for flow and vacuum and to achieve

the step test vacuum range specified in Section 4.3 and Table 6. The step test vacuum ranges shown in Table 6 account for a relatively shallow depth to water at the pilot test locations, at which high vacuum testing would have the undesired consequence of pulling groundwater into the vapor extraction test points. The step test vacuum ranges also reflect a review of project boring logs, which indicated the presence of fill/reworked materials that are unlikely to require low flow/high vacuum testing in the anticipated area of influence of the vapor extraction test points.

Soil vapor from the extraction points will be conveyed in temporary above-grade PVC piping and/or flexible hoses to a vapor-liquid separator where entrained water will be removed prior to vapor phase treatment. Based on the relatively short duration of the pilot tests, the volume of condensate generated during pilot testing is expected to be small. In the event that the volume of condensate that accumulates in the liquid condensate tank during a constant rate test at a vapor extraction point is sufficient to fill three 40-milliliter (mL) volatile organic analysis (VOA) vials, a sample of the condensate will be collected for laboratory analysis of PCE, TCE, 1,1,1-TCA, 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), and trans-1,2-dichloroethene (trans-1-2-DCE). VOC concentration data from the condensate samples will be used to manage condensate addition to the existing groundwater treatment system such that adequate treatment and discharge standards are achieved. The condensate will be pumped from the vapor-liquid separator into 55-gallon drums, as necessary, and then incorporated/bled into the groundwater influent to the existing on-Property groundwater treatment system for treatment.

The soil vapor will be drawn into the vacuum blower, followed by treatment with GAC to remove VOCs before being discharged to the atmosphere via an exhaust stack from the vapor treatment unit. Sub-slab vapor data collected in 2010 and 2011 (summarized in Section 3.4) provide characterization of the influent air (i.e., vapor extracted during pilot testing) to the vapor treatment system. These data will be used to appropriately size the GAC treatment system for the expected VOC concentrations in the pilot test vapor stream. Influent air will be monitored at

the influent to the blower for total VOC concentration (parts per million by volume [ppmv] using a photoionization detector [PID]) on each day of operation (see Section 4.4 and Table 7).

Monitoring of effluent (treated) air will occur following GAC treatment. Effluent air will be monitored at the outlet of the GAC treatment system for total VOC concentration (ppmv using a PID) on each day of operation (see Section 4.4 and Table 7). A PID with an ionization potential of 11.7 electron volts (eV) will be used for monitoring.

Monitoring of the influent and effluent air streams will be conducted to ensure appropriate frequency of GAC change out and compliance with vapor discharge standards. The pilot test vapor stream will be directed through two vapor phase GAC treatment canisters connected in series. A third, clean carbon canister will always be available on-Property for change out of the primary canister as necessary (i.e., if initial VOC concentrations exceed expected concentrations). Monitoring of the influent air will be performed using a PID before the vapor stream enters the first treatment canister. Monitoring with a PID also will be conducted between the two treatment canisters and at the exhaust of the second treatment canister (effluent air). A PID with an ionization potential of 11.7 eV will be used for monitoring. If the PID-measured total VOC concentration in the effluent air equals or exceeds 1 ppmv above background, the primary canister will be removed from the treatment system, the secondary canister will be sequenced as the primary unit, and the third canister will be sequenced as the secondary unit. For worker safety, the vapor influent stream to the GAC treatment system will be stopped during canister changeout. Spent GAC will be transported off-Property for regeneration or disposal at a permitted facility.

Five vapor extraction pilot testing locations are proposed, as shown on Figure 9:

- one location in the “waste-oil contamination area” (SVE-1), outside the Building B footprint and near the area where asphalt cover transitions to soil cover;
- one location within the modified footprint of Building B (i.e., the former loading dock area) in the area of highest anticipated VOC impact to soil and groundwater (SVE-2);
- one location near the former “gutter” in Building B in the area of highest observed VOC impact to sub-slab vapor in 2010 and 2011 samples (SVE-3);

- one location in Building B west of the original exterior perimeter footings and near monitoring well UC35, where elevated PCE concentrations were reported in shallow soil samples (SVE-4); and
- one location outside of Building B in the area of former test pits TPI and TPM in an area of historically high VOC concentrations in soil (SVE-5), in response to General Comment #4 and Specific Comment #11 in USEPA's February Comment Letter.

Proposed test point SVE-1 is located within the paved area of the Property approximately 15 feet northeast of the northeast corner of the on-Property building. Although the thickness of soil cover provided by the hill and retaining wall area is expected to prevent short circuiting from nearby unpaved areas, observation points will be installed within and outside the paved area to evaluate potential short circuiting during testing (observation points are shown on the "SVE-1 Test Point and Observation Point Detail" map on Figure 10). The need for actions to prevent short-circuiting from nearby unpaved areas during full-scale system implementation will be evaluated based on the SVE-1 pilot test and observation point response results.

In the February Comment Letter, USEPA requested that, if a sufficient vertical interval of unsaturated bedrock remains at SVE-2, a second vapor extraction point be discretely installed in the unsaturated bedrock to evaluate vapor recovery and VOC concentrations above the water table (General Comment #5). As discussed in Section 3.4 of this Work Plan, UniFirst has proposed implementation of ISCO to reduce source area mass in bedrock at and in the vicinity of UC8. Because UniFirst proposes to implement ISCO to reduce PCE mass in shallow bedrock near monitoring well UC8, a vapor extraction test point in unsaturated bedrock will not be installed in this area.

In the February Comment Letter, USEPA noted that test pits TPI and TPM may have been covered with a permeable surface rather than asphalt, and that additional low permeable materials may need to be placed over the more permeable surfaces to limit short circuiting of ambient air in this area. The need for addition of low permeability material in this area to prevent short circuiting during full-scale system implementation will be evaluated based on the SVE-5 pilot test and observation point response results; observation points for the SVE-5 test point are shown on the "SVE-5 Test Point and Observation Point Detail" map on Figure 10.

The pilot testing will be conducted in two phases: individual stepped vacuum tests and follow-up constant vacuum tests. The purpose of applying vacuum at sequentially increasing steps is to provide information regarding the relationship of applied vacuum to the ROI and the *ex situ* flow velocity of soil gas extracted from the test point, and to monitor potential vacuum-induced groundwater upwelling as sequentially higher vacuums are applied at the vapor extraction test point. Vacuum, *ex situ* air flow velocity, and water level will be measured for each vapor extraction test point throughout the duration of the step test at that point. In addition, vacuum response will be measured at observation points located near the test point (Figure 10). The pilot testing incorporates monitoring to identify potential interference by subsurface structures that may influence extraction point ROI through measurement of vacuum response at the observation points associated with each vapor extraction test point. For example, the response at observation points SVM-7 through SVM-11, SVM-15, SVM-24, and SVM-25 to the applied vacuum at test point SVE-2 will be used to evaluate potential interference from subsurface structures in this area. As a second example, the response at observation points SV-05 through SV-07 and SV-13 to the applied vacuum at test point SSVE-1 will be used to evaluate potential interference from subsurface structures in this area.

A sample port will be installed at each vapor extraction test point wellhead to assess mass removal rate and VOC constituent concentrations at each test location. As described in Section 4.4 and Table 7, collection of soil gas samples for laboratory analysis from the vapor extraction test points will be conducted three times during the constant rate test: one at startup (i.e., within approximately two hours of the start of applied vacuum), one at approximately mid-test, and one immediately before shutdown. These data will be used to estimate VOC removal at each test point and to calculate total VOC removal during pilot testing. Proposed step and constant rate testing and monitoring procedures are described in Sections 4.3 and 4.4, respectively.

4.2 VAPOR EXTRACTION POINT CONSTRUCTION

Figure 9 shows the approximate locations of the five vapor extraction points proposed for pilot testing (SVE-1 through SVE-5). Locations may be adjusted in the field to accommodate

structural features, access limitations, and/or subsurface utility locations. A schematic for a typical vapor extraction point is included in Appendix A (Figure A-1). Points will be installed to a total depth of up to approximately 1 to 2 feet above the water table at the time of installation or to bedrock, whichever is shallower. Points will be fully screened from approximately 3 feet bts/bgs to total depth. Vapor extraction points will be installed using a Geoprobe rig, hollow-stem auger rig, or hand auger, depending on drilling conditions and physical access constraints. Continuous core will be collected, logged, and screened using a field PID. Although NAPL has not been observed in any well since shortly after installation of UC8 in the 1980s, the field crew will be prepared to construct a sump to facilitate extraction of mobile NAPL in the event that it is encountered during vapor extraction point installation.

In response to USEPA's comments in the February Comment Letter, soil samples for laboratory analysis and hydrophobic dye testing will be collected from the core obtained during installation of vapor extraction points SVE-1 through SVE-5. At each location, one sample of fill/reworked materials and one sample of till, if present, will be submitted for laboratory analysis. Samples will be collected from a stained interval (if visible impact is observed) or from the interval with the highest PID reading (if visible impact is not observed). If PID readings along the soil core do not exceed background, the soil samples for laboratory analysis will be collected from the bottom of the most permeable lithologic unit. This is intended to target current or former horizons where DNAPL migration and/or pooling may have occurred. Soil samples will be collected using a Terra Core® sampler or other suitable coring device. The sample collection procedure is described in Form E of the QAPP (Attachment 1). Soil samples will be analyzed for chloroform, PCE, TCE, trans-1,2-dichloroethene (trans-1,2-DCE), and 1,1,1-TCA. Soil samples for hydrophobic dye testing will be collected after soil samples for laboratory analysis have been collected. A soil sample for hydrophobic dye testing will be collected from each interval where NAPL, sheen, or staining is observed, or where an abrupt increase in PID reading is noted. The sample collection and hydrophobic dye testing procedure is described in Form E of the QAPP (Attachment 1). If the hydrophobic dye testing indicates evidence of the presence of NAPL in the soil sample, a notation will be made on the test point

boring log. This additional soil characterization will include test point SVE-3 located in the “gutter” trench and sewer line area referred to in General Comment #6 and Specific Comment #7 of the February Comment Letter.

In response to USEPA’s comment at the June 12, 2012 meeting, the boring for vapor extraction point SVE-2 will be extended to bedrock so that unconsolidated deposits to bedrock can be evaluated for DNAPL screening via hydrophobic dye testing. As discussed above, a soil sample for hydrophobic dye testing will be collected from each interval where NAPL, sheen, or staining is observed, or where an abrupt increase in PID reading is noted.

Vapor extraction points will be constructed of nominal 2-inch diameter, schedule 40 PVC with a 0.040-inch factory slotted well screen. The annulus surrounding the screened interval will be filled with gravel filter pack from the bottom of the boring up to approximately 0.5 foot above the top of the screened interval. Above the gravel filter pack, a field-hydrated bentonite (medium chips) seal will be installed to within approximately 2 feet bts/bgs, either within or outside the building. Each vapor extraction point will be completed with a flush-mounted protective cover.

The mobile blower system will be connected to the extraction point casing using flexible hoses, cam lock connectors, and wellhead fittings. The extraction point casing will be disconnected from the mobile blower system and the well box cover will be closed during non-operation of the point.

Existing monitoring wells UC32, UC33, UC34, UC35, and UC36 and sub-slab soil vapor sampling locations SV-06, SV-10, SV-11, SV-12, SV-13, and SV-15 are targeted observation points for vacuum monitoring during the pilot testing. The monitoring wells are water table groundwater wells with screened intervals that are either typically dry or are positioned with several feet of screen above the water table (open to the vadose zone). A total of 31 soil vapor monitoring observation points (SVM-1 through SVM-31; Figure 10) will be installed to augment the targeted existing observation points, for a total of 42 potential pilot test observations points.

As shown on Figure 10, observation points for each SVE test point are arranged in multi-point arrays to support assessment of possible anisotropy in extraction point ROI. SVM points will be constructed of nominal 1-inch diameter, schedule 40 PVC with a 0.040-inch factory slotted well screen, and installed similarly to the vapor extraction points. A schematic showing a typical SVM point installation is included in Appendix A (Figure A-1). The screened interval for each SVM point will be determined based on observed lithology and the screened depth of the associated vapor extraction point.

In response to USEPA's comments in the February Comment Letter, soil samples for hydrophobic dye testing will be collected from the core obtained during installation of observation points SVM-1 through SVM-31. A soil sample for hydrophobic dye testing will be collected from each interval where NAPL, sheen, or staining is observed, or where an abrupt increase in PID reading is noted. The sample collection and hydrophobic dye testing procedure is described in Form E of the QAPP (Attachment 1). If the hydrophobic dye testing indicates evidence of the presence of NAPL in the soil sample, a notation will be made on the observation point boring log. This additional soil characterization will include observation points SVM-16 through SVM-19 located in the "gutter" trench and sewer line area referred to in General Comment #6 and Specific Comment #7 of the February Comment Letter.

Based on historical information indicating the presence of an asphalt layer at depth in the vicinity of SVE-2, paired shallow and deep observation points with short screen intervals may be installed at locations SVM-12, SVM-13, and SVM-14, rather than a single long screen interval point. One or more of the deeper points will be installed in the denser unsaturated till, if encountered, to facilitate assessment of differences in the ROI between less dense soils and denser till units. Final observation point design in this area will be based on field observations.

Investigation derived waste (IDW) (e.g., decontamination water, drill cuttings) generated during installation of pilot test points will be containerized on the Property and characterized as required by a licensed treatment and/or disposal facility prior to shipment.

4.3 STEP TESTING AND MONITORING PROCEDURES

The step test procedure was developed to evaluate vapor extraction well ROI, *ex situ* air flow velocities, and VOC mass removal rates from individual points during testing. Anticipated step test vacuums and durations are provided in Table 6. A mobile blower and off-gas treatment system will be used to apply vacuum to the vapor extraction points for each of the step tests, and to remove VOCs from the vapor stream prior to discharge to the atmosphere. During each step in the step test, the applied vacuum will be held approximately constant for up to two hours before increasing the vacuum to the next successive step. The target range of applied vacuum at each vapor extraction point will be approximately 10 to 40 "H₂O; higher vacuums will be tested if groundwater upwelling is not observed at 40 "H₂O vacuum. At least three different vacuum steps will be attempted in each step test.

During each step in the step tests, the applied vacuum, *ex situ* air velocity, temperature, and PID concentration of the effluent stream from the vapor extraction point will be measured. Samples of the vapor effluent stream for PID monitoring will be collected using a disposable Tedlar® bag placed in a vacuum box connected to a sampling port on the vapor effluent line. The sampling procedure is described in Form E of the QAPP (Attachment 1). A Standard Operating Procedure (SOP) that describes the procedure for collecting samples of the vapor effluent stream for PID monitoring also is provided with the QAPP. A PID with an ionization potential of 11.7 eV will be used for monitoring. Each vapor extraction point also will be instrumented with a pressure transducer to monitor potential vacuum-induced groundwater mounding during each step. Groundwater mounding caused by an increasing applied vacuum is likely to result in a decrease in air flow velocity due to the reduction in the amount of the well screen that is available for air flow. As noted above, vapor extraction test points will be constructed so that the bottom of the screen is approximately 1 to 2 feet above either the water table at the time of installation or top of bedrock, whichever is shallower.

In addition to the vapor extraction point data, the following key treatment system parameters will be measured during each step:

- Dilution air vacuum, velocity, and temperature;
- PID concentration of the treatment system effluent; and
- Liquid condensate production in the vapor-liquid separator.

The response vacuum in the subsurface surrounding the vapor extraction point will be measured using a handheld manometer or vacuum gauge at nearby SVM points, and targeted existing groundwater monitoring wells and sub-slab vapor points. The targeted observation points for each test point are shown on Figure 10. Field observations and measurements will be recorded on field data sheets. Field measurements will be performed in accordance with standard operating procedures to ensure data quality.

4.4 CONSTANT RATE TESTING AND MONITORING PROCEDURES

Data collected during the step tests will be used to select a constant rate test vacuum for one constant rate test at each SVE test point, based on the relationship of applied vacuum to ROI, extracted air flow velocities, and potential for vacuum-induced groundwater mounding observed during step testing. The objective of the constant rate testing is to allow each vapor extraction point to operate under a constant applied vacuum for a period longer than a step test interval to better understand the likely full-scale ROI, air permeability, air flow velocity, and extracted vapor stream VOC concentration under a constant applied vacuum condition. ROI and air permeability data from each vapor extraction location will be used to determine the likely zone of influence for full-scale wellhead placement.

The anticipated duration for each constant rate test is expected to be approximately 48 hours, but the duration may be shortened or extended based on responses observed during testing. The system will be monitored, and adjusted when necessary, throughout the duration of the constant rate test at each point to ensure that the system operates as closely as possible to the target constant applied vacuum. At the end of a particular constant rate test, an approximately 8- to 12-hour (overnight) recovery period will be allowed prior to commencing the next constant rate test.

Performance monitoring will include the collection of system operating parameters and vapor samples, as summarized in Table 7. Monitoring at each test point will include the applied vacuum, air velocity, temperature, and PID concentration for the extracted vapor stream. Samples of the vapor effluent stream for PID monitoring will be collected using a disposable Tedlar® bag placed in a vacuum box connected to a sampling port on the vapor effluent line. The sampling procedure is described in Form E of the QAPP (Attachment 1). A SOP that describes the procedure for collecting samples of the vapor effluent stream for PID monitoring also is provided with the QAPP. A PID with an ionization potential of 11.7 eV will be used for monitoring. The vapor extraction point will also be instrumented with a pressure transducer to monitor potential vacuum-induced groundwater mounding during the constant rate test. Each test point will also have a sampling port at the wellhead for collection of vapor stream samples for laboratory analysis. Three vapor samples for laboratory analysis will be collected from the vapor extraction point during the constant rate test: one at startup (i.e., within approximately two hours of the start of applied vacuum), one at approximately mid-test, and one immediately before shutdown. The sampling procedure is described in Form E of the QAPP (Attachment 1). Vapor samples will be submitted to Alpha Analytical, Inc. of Mansfield, Massachusetts (Alpha), a National Environmental Laboratory Accreditation Conference (NELAC) (E87814) certified laboratory, for laboratory analysis of VOCs by Modified EPA Method TO-15.

The response vacuum in the subsurface surrounding the vapor extraction point will be measured using a handheld manometer or vacuum gauge at nearby SVM points, and targeted existing groundwater monitoring wells and sub-slab vapor points (Figure 10). Field observations and measurements will be recorded on field data sheets. Field measurements and sample collection will be performed in accordance with standard operating procedures to ensure data quality. The mobile off-gas treatment system will be operated continuously throughout the duration of each constant rate test to remove VOCs from the extracted soil vapor prior to discharge to the atmosphere.

Consistent with the Massachusetts Department of Environmental Protection (MassDEP) policy for point source remedial air emissions, performance monitoring data will be collected that satisfies MassDEP requirements as follows:

- Influent and effluent vapor samples will be obtained from the vapor influent and effluent streams daily after system startup. Vapor samples will be analyzed for total VOC concentration (parts per billion by volume) using a field PID;
- Documentation will be maintained detailing the daily instrument calibration procedure for the field PID. At a minimum, the PID instrument will be calibrated at the beginning of each work day and the calibration will be checked twice daily (midday and at the end of the day). The PID will be recalibrated if the calibration checks indicate a significant variation from the standard. The PID will be replaced if it cannot be recalibrated consistent with the SOP provided with the QAPP (Attachment 1). An extra PID will be available on-Property throughout the pilot testing.

4.5 SHALLOW VAPOR EXTRACTION TESTING

If the pilot testing results support the proposed design and implementation of a full-scale vapor extraction system at the Property, shallow sub-slab vapor extraction (SSVE) points may be installed and operated concurrent with the vapor extraction points to prevent vapor intrusion into portions of Building B and Building C, if necessary. Neither characterization nor historical operational data indicate sub-slab vapor concentrations of concern beneath Building A; thus no vapor intrusion mitigation efforts are proposed for this building.

During the pilot testing, two SSVE points will be installed (one point in Building B and one point in Building C) and tested to evaluate the influence area for a sub-slab vacuum induced at each location and the likely VOC mass loading for off-gas treatment. One SSVE point will be installed in Building B near former sub-slab vapor sampling location SV-07 (SSVE-1; Figure 9). Existing sub-slab vapor testing location SV-07 and five additional existing sub-slab vapor testing locations (SV-04, SV-05, SV-06, SV-10, and SV-13) will be used initially to assess the ROI of the vacuum applied at SSVE-1. Figure 11 shows the test point and target observation points for SSVE-1. If vacuum response is not observed in these target observation points, additional small-diameter penetrations through the floor slab may be made using a hand drill to evaluate ROI.

One SSVE point will be installed in Building C near former sub-slab vapor sampling location SV-09 (SSVE-2; Figure 9). As demonstrated previously (see Section 3.4), VOC impact to sub-slab vapor in this area is a result of constituents volatilizing from groundwater. No operations with the potential to impact unconsolidated deposits were conducted historically in this building. Existing sub-slab vapor testing location SV-09 and four new small-diameter slab penetrations made using a hand drill will be used to assess the ROI of the vacuum applied at SSVE-2. Figure 11 shows the test point and target observation points for SSVE-2. If vacuum response is not observed in these target observation points, additional small-diameter penetrations through the Building C floor slab may be made using a hand drill to evaluate ROI.

Each SSVE point will be installed using a concrete core drill and hand tools (i.e., hand auger, trowel, etc.). An approximately 5-inch diameter hole will be cored through the concrete floor slab, and underlying soil will be removed to a depth of approximately one foot below the bottom of the concrete slab. The hole will be backfilled with gravel up to the bottom of the concrete slab, and a 2-inch diameter, schedule 40 PVC pipe will be sealed in place through the concrete corehole using Type S mortar or cement grout to facilitate hookup to the blower for testing. A typical SSVE point schematic is provided in Appendix A (Figure A-2). SSVE point locations may be adjusted in the field to accommodate structural features, access limitations, and/or sub-slab utility locations. Soil removed during installation of the two SSVE points will be screened in the field using a PID with an ionization potential of 11.7 eV. If the PID screening indicates potential soil contamination, a sample will be collected for laboratory analysis. Soil samples will be collected using a Terra Core® sampler or other suitable coring device. The sample collection procedure is described in Form E of the QAPP (Attachment 1).

Soil samples will be analyzed for chloroform, PCE, TCE, trans-1,2-DCE, and 1,1,1-TCA. If NAPL, sheen, or staining is observed in the soil removed during installation of the SSVE test point, or if an abrupt increase in PID reading is noted, a sample will be collected for hydrophobic dye testing. Soil samples for hydrophobic dye testing will be collected after soil samples for laboratory analysis have been collected. The sample collection and hydrophobic dye

testing procedure is described in Form E of the QAPP (Attachment 1). If the hydrophobic dye testing indicates evidence of the presence of NAPL in the soil sample, a notation will be made on the SSVE point installation log. IDW generated during installation of SSVE points will be containerized on the Property and characterized as required by a licensed treatment and/or disposal facility prior to shipment.

The anticipated applied vacuum and duration for the SSVE point evaluation are described in Table 6. A hand-held manometer or vacuum gauge will be used to measure sub-slab vacuum at the target observation points during testing. The vacuum measurement device will be sealed in place at the observation point using either the existing fitting (for previous sub-slab soil vapor sampling locations) or a permagum (Virginia Kmp PP-22 Sealing Gum) seal with the slab penetration. New slab penetrations will be sealed temporarily with permagum while not in use for ROI observation, and sealed with hydraulic cement following completion of testing. Slab penetrations sealed with hydraulic cement can be reopened if necessary, similar to the SV points installed for the 2010 and 2011 sub-slab testing.

5.0 REPORTING

A report describing the results of the pilot testing will be prepared and presented to USEPA within 90 days of completion of the pilot testing. Reporting for the pilot testing will include completed field forms and laboratory reports for samples analyzed by Alpha.

The report will present recommendations for scale-up of the vapor extraction system, if the pilot testing results confirm that a system can prevent vapor intrusion into the on-Property building and that VOC-impacted unsaturated unconsolidated deposits at the Property are amenable to treatment by vapor extraction. In that event, data collected during the pilot testing will be used to determine the final well field design, anticipated mass removal rate of VOCs, and other requirements for a full-scale system.

6.0 SCHEDULE

Field planning for the pilot testing will be initiated following USEPA approval of this Revised Work Plan and QAPP (Attachment 1). Approximately four weeks of field planning

will be required prior to initiating pilot testing. The pilot testing program will then be conducted over an approximately four week period, which will include approximately 1.5 weeks of setup and step testing (assumes one day per point) and approximately 2.5 weeks of constant rate testing (assumes 48 hours per vapor extraction point) and demobilization. Receipt and validation of laboratory analytical data is anticipated to be complete approximately six weeks following conclusion of the pilot testing. The proposed timeline for implementation of the pilot test and subsequent pilot test report preparation is provided in Form D of the QAPP.

6.1 PERMITTING

An air permit is not required from MassDEP unless VOC discharges would exceed 1 ton per year (with or without off-gas treatment). Off-gas discharges during pilot testing will be directed through a vapor treatment system that will reduce discharge VOC vapor concentrations consistent with MassDEP requirements.

No permits will be required for installation of the proposed vapor extraction or observation points.

7.0 REFERENCES

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TABLES

Table 1
Depth to Water Table Measurements
April 2009 and September 2010
UniFirst Property
Woburn, MA

Well	April 2009 Depth to Water (feet bgs)	September 2010 Depth to Water (feet bgs)
S70D	11.82	15.79
S70M	8.88	1.41
S70S	12.28	15.99
S71D	10.33	16.12
S71S	10.02	14.99
UC10-4	15.52	23.47
UC10D	10.76	14.50
UC10M	10.70	13.60
UC10S	10.21	13.37
UC15D	26.34	40.35
UC15S	15.10	19.97
UC16	11.21	17.26
UC17	8.15	18.93
UC18	13.02	17.78
UC19	12.77	19.07
UC19M	8.96	13.99
UC19S	9.19	13.95
UC20	18.15	12.71
UC22	61.75	77.47
UC22	61.75	77.47
UC23-5	49.70	26.70

Well	April 2009 Depth to Water (feet bgs)	September 2010 Depth to Water (feet bgs)
UC24D	12.22	16.27
UC24S	12.09	16.04
UC25	10.02	Dry (>11.97)
UC26D	10.42	14.47
UC26S	9.54	13.49
UC29D	9.36	NM
UC29S	NM	14.44
UC30	12.16	Dry (>14.04)
UC31D	11.87	16.27
UC31S	10.13	15.88
UC32	5.12	Dry (>5.80)
UC33	7.60	9.42
UC34	Dry (>5.80)	Dry (>5.80)
UC35	Dry (>7.70)	Dry (>7.70)
UC36	Dry (>6.30)	Dry (>6.30)
UC4	6.03	10.71
UC5	9.83	10.56
UC6	10.71	14.83
UC6S	9.78	13.82
UC7A-5	4.21	3.35
UC8	4.51	10.28

ABBREVIATION:

bgs = below ground surface

Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Methanol-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
B1	B1MAA	.05-2.5	Jun-18 -92	8010	330	43U	43U	43U	43U	43U	43U	43U
	B1MBA	4.5-6.5	Jun-18 -92	8010	120	45U	45U	45U	45U	45U	45U	45U
B2	B2MAA	.05-2.5	Jun-18 -92	8010	120	41U	41U	41U	41U	41U	41U	41U
	B2MBA	3.0-4.5	Jun-18 -92	8010	44U	44U	44U	44U	44U	44U	44U	44U
B3	B3MAA	.05-2.5	Jun-18 -92	8010	1400	89U	89U	290	89U	89U	89U	89U
	B3MBA	2.5-4.5	Jun-18 -92	8010	42U	42U	42U	42U	42U	42U	42U	42U
B4	B4MAA	.05-2.5	Jun-18 -92	8010	59,000	1500	4600	360U	360U	360U	360U	360U
B5	B5MAA	.05-2.5	Jun-19-92	8010	82	47U	47U	47U	47U	47U	47U	47U
	B5MBA	4.5-6.5	Jun-19-92	8010	580	47U	47U	47U	47U	47U	47U	47U
B6	B6MAA	.05-2.5	Jun-18 -92	8010	51	46U	46U	46U	46U	46U	46U	46U
B7	B7MAA	.05-2.5	Jun-19-92	8010	1700	280U	12,000	280U	280U	280U	280U	280U
	B7MBA	2.5-3.7	Jun-19-92	8010	48U	48U	48U	48U	48U	48U	48U	48U
VB1	VB1-1	.25-2.25	Feb-23-89	3580/8000	580	38U	38U	NA	NA	NA	95U	NA
	VB1-2	2.25-3.25	Feb-23-89	3580/8000	2500	500U	8.6U	NA	NA	NA	21U	NA
VB2	VB2-1	.25-2.25	Feb-23-89	3580/8000	1200	640	34U	NA	NA	NA	85U	NA
	VB2-2	2.25-4.25	Feb-23-89	3580/8000	82	17	9.4U	NA	NA	NA	24U	NA
	VB2-3	4.25-5.25	Feb-23-89	3580/8000	57	13U	13U	NA	NA	NA	33U	NA
VB3	VB3-1	.25-2.25	Feb-23-89	3580/8000	22U	22U	22U	NA	NA	NA	56U	NA
	VB3-2	2.25-4.25	Feb-23-89	3580/8000	16U	16U	16U	NA	NA	NA	500	NA
	VB3-3	4.25-6.0	Feb-23-89	3580/8000	79	13U	13U	NA	NA	NA	580	NA
	VB3-4	0.25-2.25	Feb-23-89	3580/8000	11U	11U	11U	NA	NA	NA	11U	NA
	VB3-5	2.25-4.25	Feb-23-89	3580/8000	54	9.5U	9.5U	NA	NA	NA	430	NA
	VB3-6	4.25-6.0	Feb-23-89	3580/8000	110	73	7.8U	NA	NA	NA	7.8U	NA
VB4	VB4-1M	0.5-2	Mar-2-89	3580/8000	6500	1400U	220	NA	NA	NA	36U	NA
	VB4-2M	2-3.7	Mar-2-89	3580/8000	700U	1400U	3000	NA	NA	NA	36U	NA
VB5	VB5-1M	0.5-2	Mar-2-89	3580/8000	23,000	1400U	800	NA	NA	NA	36U	NA
	VB5-2M	2-3.7	Mar-2-89	3580/8000	1200	1400U	1200	NA	NA	NA	36U	NA
UC27	C273A	3.5-4.0	Dec-3-93	8240	20,000	600U	600U	NA	600U	600U	600U	1200U
	C276A	10.0-11.0	Dec-3-93	8240	620	140U	140U	NA	140U	140U	140U	290U
UC28	C281A	0-1.0	Dec-3-93	8240	110J	140U	140U	NA	140U	140U	140U	280U
	C284A	6.0-8.0	Dec-3-93	8240	160U	160U	160U	NA	160U	160U	160U	320U

Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Methanol-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
UC29D	29D1A	0-2.0	Dec-3-93	8240	190U	190U	190U	NA	190U	190U	190U	380U
	29D3A	2.0-4.0	Dec-3-93	8240	180U	180U	180U	NA	180U	180U	180U	360U
	29D5A	8.0-10.0	Dec-3-93	8240	38J	170U	170U	NA	170U	170U	170U	330U
	29D5B	8.0-10.0	Dec-3-93	8240	100J	210U	210U	NA	210U	210U	210U	430U
UC30	C301A	0-2.0	Dec-8-93	8240	240U	240U	240U	NA	240U	240U	240U	490U
	C303A	4.0-6.0	Dec-8-93	8240	160U	160U	160U	NA	160U	160U	160U	310U
	C305A	8.0-10.0	Dec-8-93	8240	170U	170U	170U	NA	170U	170U	170U	350U
	C307A	12.0-14.0	Dec-8-93	8240	230U	230U	230U	NA	230U	230U	230U	450U
UC32	C321A	2.0-3.5	Mar-30-94	8240	260U	260U	260U	NA	260U	260U	260U	260U
	C322A	5.5-6.8	Mar-30-94	8240	50J	270U	270U	NA	270U	270U	270U	270U
UC33	C331A	2.0-3.5	Apr-4-94	8240	200U	200U	200U	NA	200U	200U	200U	200U
	C332A	5.5-7.5	Apr-5-94	8240	220U	220U	220U	NA	220U	220U	220U	220U
	C333A	9.0-10.5	Apr-5-94	8240	220U	220U	220U	NA	220U	220U	220U	220U
	C334A	10.5-11.25	Apr-5-94	8240	110J	340U	340U	NA	340U	340U	340U	340U
UC34	C341A	3.0-4.5	Apr-7-94	8240	4400	230U	230U	NA	230U	230U	230U	230U
	C342A	9.0-11.0	Apr-7-94	8240	230U	230U	230U	NA	230U	230U	230U	230U
UC35	C351A	0.5-2.0	Apr-12-94	8240	89000	8900D	220U	NA	220U	220U	220U	220U
	C352A	2.0-3.5	Apr-12-94	8240	2000	220U	220U	NA	220U	220U	220U	220U
	C352B	2.0-3.5	Apr-12-94	8240	1000	260U	260U	NA	260U	260U	260U	260U
	C353A	5.5-7	Apr-12-94	8240	73J	230U	230U	NA	230U	230U	230U	230U
UC36	C354A	8.5-9.35	Apr-13-94	8240	590	220U	220U	NA	220U	220U	220U	220U
	C361A	0.5-2.0	Apr-13-94	8240	130J	230U	230U	NA	230U	230U	230U	230U
	C362A	3.5-5.0	Apr-13-94	8240	84J	200U	200U	NA	200U	200U	200U	200U
	C363A	5.0-6.5	Apr-13-94	8240	290	200U	200U	NA	200U	200U	200U	200U
Waste Oil Contamination	C364A	6.5-7.7	Apr-13-94	8240	300	180U	180U	NA	180U	180U	180U	180U
	SS1MA		Aug-31-92	8240	210,000	14,000U	14,000U	NA	14,000U	14,000U	14,000U	27,000U
	SS1MB		Aug-31-92	8240	130,000	14,000U	14,000U	NA	14,000U	14,000U	14,000U	27,000U

Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Methanol-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
TPC	TPC-1A	4.8	Jul-31-92	8240	580	280U	280U	NA	280U	280U	NA	550U
	TPC-2A	4.8	Jul-31-92	8240	210J	280U	280U	NA	280U	280U	NA	560U
	TPC-3A	2.2	Jul-31-92	8240	180J	280U	280U	NA	280U	280U	NA	560U
	TPC-4A	3.8	Jul-31-92	8240	680	260U	260U	NA	260U	260U	NA	520U
TPD	TPD-1A	5.2	Jul-31-92	8240	810	280U	280U	NA	280U	280U	NA	570U
	TPD-1B	5.2	Jul-31-92	8240	350	310U	310U	NA	310U	310U	NA	610U
	TPD-2A	3.9	Jul-31-92	8240	250U	250U	250U	NA	250U	250U	NA	500U
	TPD-3A	2.5	Jul-31-92	8240	150J	290U	290U	NA	290U	290U	NA	570U
TPE	TPE-1A	3.7	Aug-24-92	8240	450U	450U	450U	NA	450U	450U	NA	900U
	TPE-2A	3.7	Aug-24-92	8240	410J	540U	540U	NA	540U	540U	NA	1100U
	TPE-3A	2.5	Aug-24-92	8240	800U	800U	800U	NA	800U	800U	NA	1600U
	TPE-4A	1.0	Aug-24-92	8240	580	440U	440U	NA	170JX	440U	NA	880U
	TPE-4B	1.0	Aug-24-92	8240	450J	560U	560U	NA	560U	560U	NA	1100U
	TPE-5A	3.7	Aug-24-92	8240	140J	450U	450U	NA	450U	450U	NA	900U
TPF	TPF1A	2.5	Sep-22-92	8240	2,300,000	5,0000U	5,0000U	NA	5,0000U	5,0000U	NA	1,00000U
	TPF2A	3.5	Sep-22-92	8240	1200	250U	250U	NA	250U	250U	NA	500U
	TPF3A	1.7	Sep-22-92	8240	250U	250U	250U	NA	250U	250U	NA	500U
	TPF4A	0.6	Sep-22-92	8240	750	290U	290U	NA	290U	290U	NA	580U
	TPF5A	3.9	Sep-22-92	8240	1100	360U	360U	NA	360U	360U	NA	720U
	TPF6A	5.5	Sep-22-92	8240	300U	300U	300U	NA	300U	300U	NA	600U
	TPF7A	3.5	Sep-22-92	8240	47,000	2800U	2800U	NA	2800U	2800U	NA	5500U
	TPF8A	4.5	Sep-22-92	8240	710	300U	300U	NA	300U	300U	NA	590U
TPG	TPF9A	6.9	Sep-22-92	8240	1200	280U	280U	NA	280U	280U	NA	570U
	TPG1A	2.0	Sep-22-92	8240	310	160U	160U	NA	160U	160U	NA	310U
	TPG2A	3.3	Sep-22-92	8240	20,000	490U	490U	NA	490U	490U	NA	980U
	TPG3A	0.8	Sep-22-92	8240	5700	280U	280U	NA	280U	280U	NA	570U
	TPG4A	2.6	Sep-22-92	8240	720	280U	280U	NA	280U	280U	NA	570U
	TPG5A	4.8	Sep-22-92	8240	910	310U	310U	NA	310U	310U	NA	620U
	TPG5B	4.8	Sep-22-92	8240	2,000	280U	280U	NA	280U	280U	NA	570U
	TPG6A	6.0	Sep-22-92	8240	600	280U	280U	NA	280U	280U	NA	550U
	TPG7A	1.5	Sep-22-92	8240	67,000	5,000U	5,000U	NA	5,000U	5,000U	NA	1,0000U
TPH	TPG8A	2.9	Sep-22-92	8240	2100	320U	320U	NA	320U	320U	NA	630U
	TPG9A	7.3	Sep-22-92	8240	1100	300U	300U	NA	300U	300U	NA	590U
	TPH1A	0.5	Jul-24-93	8240	270J	310U	310U	NA	310U	310U	NA	620U
	TPH2A	4.6	Jul-24-93	8240	360	170U	170U	NA	170U	170U	NA	340U
	TPH9A	4.8	Jul-24-93	8240	3400	37J	170U	NA	62J	170U	NA	340U
TPI	TPH11A	5.5	Jul-24-93	8240	2800	170U	170U	NA	64J	170U	NA	340U
	TPH1A	0.5	Jul-24-93	8240	120,000	86J	8500	NA	170U	170U	NA	350U
TPJ	TPJ1A	3.0	Dec-02-93	8240	42J	110U	110U	NA	110U	110U	110U	210U

Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Methanol-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
TPK	PK10A	4.4	Dec-03-93	8240	36J	110U	110U	NA	110U	110U	110U	230U
	PK10B	4.4	Dec-03-93	8240	37J	100U	100U	NA	100U	100U	100U	200U
TPK	PK11A	2.9	Dec-03-93	8240	93U	93U	93U	NA	93U	93U	93U	190U
	PK12A	1.9	Dec-03-93	8240	140	96U	96U	NA	96U	96U	96U	190U
TPL	TPL1A	2.1	Dec-03-93	8240	50J	91U	91U	NA	91U	91U	91U	180U
	TPL4A	2.1	Dec-03-93	8240	170	130U	130U	NA	130U	130U	130U	260U
	TPL5A	3.7	Dec-03-93	8240	110U	110U	110U	NA	110U	110U	110U	220U
TPM	TPM1A	0.0-1.0	Apr-25-94	8240	2,500,000B	140,000U	140,000U	NA	140,000U	140,000U	140,000U	140,000U
	TPM2A	4	Apr-25-94	8240	230J	390U	390U	NA	390U	390U	390U	390U
	TPM3A	2	Apr-25-94	8240	3700B	370U	370U	NA	370U	370U	370U	370U
	TPM4A	0.8	Apr-25-94	8240	220,000	14,000U	14,000U	NA	14,000U	14,000U	14,000U	14,000U
	TPM4B	0.8	Apr-25-94	8240	320,000B	18,000U	18,000U	NA	18,000U	18,000U	18,000U	18,000U
	TPM5A	0.5	Apr-25-94	8240	73,000	5100U	3300J	NA	5100U	5100U	5100U	5100U
	TPM6A	2	Apr-25-94	8240	88BJ	430U	430U	NA	430U	430U	430U	430U
	TPM7A	4	Apr-25-94	8240	620B	370U	92J	NA	370U	370U	370U	370U

ABBREVIATIONS:

ND = not detected

NA = not analyzed

U = indicates that the compound was not detected at the detection limit indicated by the preceding number

J = indicates an estimated concentration

D = indicates a diluted sample

B = indicates compound detected in blank sample

X = indicates manual edit to reporting software

- = not reported

PCE = tetrachloroethene

TCE = trichloroethene

1,1,1-TCE = 1,1,1-trichloroethane

cis-DCE = cis-1,2-dichloroethene

t-DCE = trans-1,2-dichloroethene or

1,2-dichloroethene (total), where cis-DCE is N

1,2-DCA = 1,2-dichloroethane

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Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Non-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
B1	B1SAA	.05-2.5	Jun-18-92	8010	17	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
	B1SBA	4.5-6.5	Jun-18-92	8010	2.1U	2.1U	2.1U	2.1U	2.1U	2.1U	2.1U	2.1U
B2	B2SAA	.05-2.5	Jun-18-92	8010	120	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
	B2SBA	3.0-4.5	Jun-18-92	8010	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
B3	B3SAA	.05-2.5	Jun-18-92	8010	64	3.8U	3.8U	5.4	3.8U	3.8U	3.8U	3.8U
	B3SBA	2.5-4.5	Jun-18-92	8010	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
B4	B4SAA	.05-2.5	Jun-18-92	8010	2600	86U	86U	86U	86U	86U	86U	86U
B5	B5SAA	.05-2.5	Jun-19-92	8010	5.4	2.2U	2.2U	2.2U	2.2U	2.2U	2.2U	2.2U
	B5SBA	4.5-6.5	Jun-19-92	8010	20	3.8U	3.8U	3.8U	3.8U	3.8U	3.8U	3.8U
B6	B6SAA	.05-2.5	Jun-19-92	8010	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U
B7	B7SAA	.05-2.5	Jun-19-92	8010	37	3.0U	8.0	3.0U	3.0U	3.0U	3.0U	3.0U
	B7SBA	2.5-3.7	Jun-19-92	8010	1.9U	1.9U	1.9U	1.9U	1.9U	1.9U	1.9U	1.9U
VB1	VB1-2	2.25-3.25	Feb-23-89	3580/8000	150	19U	19U	NA	NA	NA	48U	NA
VB3	VB3-5	10.0-12.0	Feb-23-89	3580/8000	28U	28U	28U	NA	NA	NA	70U	NA
UC4	UC4-SS-1	0-2.0	Nov-86		8.8	NA	NA	NA	NA	NA	NA	NA
UC5	UC5-SS-1	0-2.0	Nov-86		170	NA	12	NA	NA	NA	NA	NA
	UC5-SS-2	4.0-6.0	Nov-86		ND	NA	ND	NA	NA	NA	NA	NA
UC6	UC6-SS-1	0-2.0	Nov-86		ND	NA	ND	NA	NA	NA	NA	NA
	UC6-SS-2	2.0-4.0	Nov-86		ND	NA	ND	NA	NA	NA	NA	NA
	UC6-SS-3	4.0-6.0	Nov-86		ND	NA	ND	NA	NA	NA	NA	NA
	UC6-SS-4	18-20	Nov-86		ND	NA	ND	NA	NA	NA	NA	NA
UC7	UC7-1	1.0	Nov-86		61	NA	ND	NA	NA	NA	NA	NA
	UC7-2	2.0	Nov-86		-	NA	ND	NA	NA	NA	NA	NA
	UC7-2D	2.0	Nov-86		10	NA	ND	NA	NA	NA	NA	NA
	UC7-SS-1A	2.0-4.0	Nov-86		NA	NA	NA	NA	NA	NA	NA	NA
	UC7-SS-2	4.0-6.0	Nov-86		NA	NA	NA	NA	NA	NA	NA	NA
	UC7-SS-3	6-6.5	Nov-86		NA	NA	NA	NA	NA	NA	NA	NA
UC15		5.0-10.0	Sep-87		ND	ND	ND	ND	ND	NA	NA	NA
UC16		2.0-5.0	Sep-87		ND	ND	ND	ND	ND	NA	NA	NA
UC17		2.0-5.0	Oct-87		290	ND	ND	ND	ND	NA	NA	NA
UC18		2.0-10.0	Oct-87		ND	ND	ND	ND	ND	NA	NA	NA
UC19		3.0-6.0	Oct-87		ND	ND	ND	ND	ND	NA	NA	NA
UC20		3.0-6.0	Oct-87		ND	ND	ND	ND	ND	NA	NA	NA

Table 2
VOC Concentrations in Unconsolidated Deposits Samples
UniFirst Property
Woburn, MA
Non-Preserved Samples

Location	Sample ID	Depth (ft)	Date of Collection	Lab Method	Concentration (micrograms per kilogram)							
					PCE	TCE	1,1,1-TCA	cis-DCE	t-DCE	1,1,-DCA	1,2-DCA	VC
Waste Oil Contamination	SS1SA	Spoil pile	Aug-31-92	5030/8240	460,000	14,000U	14,000U	NA	14,000U	14,000U	14,000U	27,000U
TPF	TPF1A	2.5	Sep-22-92	8240	35,000,000	650,000U	650,000U	NA	650,000U	650,000U	NA	1,300,000U
	TPF2A	3.5	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPF3A	1.7	Sep-22-92	8240	5.0U	5.0U	5.0U	NA	5.0U	5.0U	NA	10U
	TPF4A	0.6	Sep-22-92	8240	110	6.0U	6.0U	NA	6.0U	6.0U	NA	12U
	TPF5A	3.9	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPF6A	5.5	Sep-22-92	8240	26U	26U	26U	NA	26U	26U	NA	53U
	TPF7A	3.5	Sep-22-92	8240	9200	1300U	1300U	NA	1300U	1300U	NA	2600U
	TPF8A	4.5	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPF9A	6.9	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
TPG	TPG1A	2.0	Sep-22-92	8240	14,000	1700	650U	NA	1600	650U	NA	1300U
	TPG2A	3.3	Sep-22-92	8240	2700	750U	750U	NA	750U	750U	NA	1500U
	TPG3A	0.8	Sep-22-92	8240	760	28U	28U	NA	28U	28U	NA	55U
	TPG4A	2.6	Sep-22-92	8240	36	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPG5A	4.8	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPG5B	4.8	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPG6A	6.0	Sep-22-92	8240	5.5U	5.5U	5.5U	NA	5.5U	5.5U	NA	11U
	TPG7A	1.5	Sep-22-92	8240	22,000	3100U	3100U	NA	3100U	3100U	NA	6200U
	TPG8A	2.9	Sep-22-92	8240	5.0U	5.0U	5.0U	NA	5.0U	5.0U	NA	10U
	TPG9A	7.3	Sep-22-92	8240	10U	10U	10U	NA	10U	10U	NA	21U

ABBREVIATIONS:

ND = not detected

NA = not analyzed

U = indicates that the compound was not detected at the detection limit indicated by the preceding number

J = indicates an estimated concentration

D = indicates a diluted sample

B = indicates compound detected in blank sample

X = indicates manual edit to reporting software

- = not reported

PCE = tetrachloroethene

TCE = trichloroethene

1,1,1-TCE = 1,1,1-trichloroethane

cis-DCE = cis-1,2-dichloroethene

t-DCE = trans-1,2-dichloroethene or

1,2-dichloroethene (total), where cis-DCE is NA

1,2-DCA= 1,2-dichloroethane

Table 3
Analytical Results for Sub-Slab Vapor Samples
April 2010
UniFirst Property
Woburn, MA

Parameter	SV-01	SV-02	SV-03	SV-04	SV-05	SV-06	SV-07	SV-08	SV-09
	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010
Petroleum Hydrocarbons by EPA Method TO-15 (SIM)									
1,3-Butadiene	0.044 U	0.121 U	0.044 U	0.044 U	0.442 U	0.442 U	0.442 U	0.044 U	0.442 U
Methyl tert butyl ether	0.072 U	0.256	0.072 U	0.072 U	0.72 U	0.72 U	0.72 U	0.072 U	0.72 U
Benzene	0.319 U	0.872	0.319 U	0.319 U	3.19 U	3.19 U	3.19 U	0.319 U	3.19 U
Toluene	0.516	3.11	0.264	0.376	1.88 U	1.88 U	1.88 U	0.32	1.88 U
Ethylbenzene	0.087 U	0.534	0.087 U	0.087 U	0.868 U	0.868 U	0.868 U	0.087 U	0.868 U
Xylenes, Total	0.373	2.88	0.26 U	0.26 U	2.6 U	2.6 U	2.6 U	0.26 U	2.6 U
Naphthalene	0.26 U	1.06	0.26 U	0.26 U	2.62 U	2.62 U	2.62 U	0.26 U	2.62 U
Petroleum Hydrocarbons by MA APH									
C5-C8 Aliphatics, Adjusted	22	120	13	20	120 U	120 U	120 U	46	120 U
C9-C12 Aliphatics, Adjusted	58	490	20 U	300	140 U	140 U	140 U	86	140 U
C9-C10 Aromatics	10 U	27 U	10 U	10 U	100 U	100 U	100 U	10 U	100 U
Volatile Organic Compounds by EPA Method TO-15 (SIM)									
1,1,1-Trichloroethane	0.234	0.67	0.681	5.45	920	1440	280	2.84	33.2
1,1,2-Trichloroethane	0.109 U	0.298 U	0.109 U	0.109 U	1.09 U	1.09 U	1.09 U	0.109 U	1.09 U
1,1-Dichloroethane	0.081 U	0.221 U	0.081 U	0.081 U	0.809 U	0.809	3.52	0.081 U	0.809 U
1,1-Dichloroethene	0.079 U	0.216 U	0.079 U	0.079 U	0.792 U	0.872	0.792 U	0.079 U	0.792 U
1,2,4-Trimethylbenzene	0.098 U	0.832	0.098 U	0.108	0.982 U	1.67	0.982 U	0.098 U	0.982 U
1,2-Dibromoethane	0.077 U	0.21 U	0.077 U	0.077 U	0.768 U	0.768 U	0.768 U	0.077 U	0.768 U
1,2-Dichloroethane	0.081 U	0.221 U	0.081 U	0.081 U	0.809 U	0.809 U	0.809 U	0.081 U	0.809 U
1,2-Dichloropropane	0.092 U	0.252 U	0.092 U	0.092 U	0.924 U	0.924 U	0.924 U	0.092 U	0.924 U
1,3-Dichlorobenzene	0.12 U	0.328 U	0.12 U	0.12 U	1.2 U	1.2 U	1.2 U	0.12 U	1.2 U
1,4-Dichlorobenzene	0.342	1.15	0.234	0.186	1.2 U	1.2 U	1.2 U	0.12 U	1.2 U
Bromodichloromethane	0.067 U	0.183 U	0.067 U	0.067 U	0.67 U	0.67 U	0.67 U	0.074 J	0.67 U
Bromoform	0.206 U	0.564 U	0.206 U	0.206 U	2.06 U	2.06 U	2.06 U	0.206 U	2.06 U
Carbon tetrachloride	0.126 U	0.344 U	0.126 U	0.214	1.26 U	1.26 U	1.26 U	0.283	1.26 U
Chlorobenzene	0.092 U	0.251 U	0.092 U	0.092 U	0.92 U	1.52	0.92 U	0.092 U	0.92 U
Chloroform	0.854	1	0.098 U	0.098 U	1.22	16.6	2.58	7.74	0.976 U
cis-1,2-Dichloroethene	0.079 U	0.216 U	0.079 U	0.079 U	0.792 U	0.792 U	0.792 U	0.079 U	0.792 U
Isopropylbenzene	2.46 U	6.71 U	2.46 U	2.46 U	24.6 U	24.6 U	24.6 U	2.46 U	24.6 U
Methylene chloride	1.74 U	4.74 U	1.74 U	1.74 U	17.4 U	17.4 U	17.4 U	1.74 U	17.4 U
Tetrachloroethene	68	923	255	201	203000	420000	169000	3920	25100
trans-1,2-Dichloroethene	0.079 U	0.216 U	0.079 U	0.079 U	0.792 U	0.792 U	0.792 U	0.079 U	0.792 U
trans-1,3-Dichloropropene	0.091 UJ	0.248 UJ	0.091 UJ	0.091 UJ	0.907 UJ	0.907 UJ	0.907 UJ	0.091 UJ	0.907 UJ
Trichloroethene	0.107 U	0.293 U	0.107 U	0.107 U	7.2	522	13.9	0.247	4.51
Vinyl chloride	0.051 U	0.14 U	0.051 U	0.051 U	0.511 U	0.511 U	0.511 U	0.051 U	0.511 U

NOTE:

All concentrations reported in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

ABBREVIATIONS:

U = Compound not detected above presented reporting limit

UJ = Compound not detected; approximate reporting limit presented

J = Compound detected below reporting limit; estimated concentration presented

APH = Massachusetts Air-Phase Petroleum Hydrocarbons Method

TO-15-SIM = Modified EPA Method TO-15 (Selected Ion Monitoring)

Table 3
Analytical Results for Sub-Slab Vapor Samples
April 2010
UniFirst Property
Woburn, MA

Parameter	SV-10	SV-11	SV-11 Duplicate	SV-12	SV-13	SV-13 Duplicate	SV-14	SV-15
	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010	4/12/2010
Petroleum Hydrocarbons by EPA Method TO-15 (SIM)								
1,3-Butadiene	0.442 U	0.442 U	0.416 U	0.442 U	0.442 U	0.442 U	0.044 U	0.442 U
Methyl tert butyl ether	0.72 U	0.72 U	0.678 U	0.72 U	0.72 U	0.72 U	0.072 U	0.72 U
Benzene	3.19 U	3.19 U	3 U	3.19 U	3.19 U	3.19 U	0.319 U	3.19 U
Toluene	1.88 U	1.88 U	1.77 U	1.88 U	1.88 U	1.88 U	0.29	1.88 U
Ethylbenzene	0.868 U	0.868 U	0.816 U	0.868 U	0.868 U	0.868 U	0.087 U	0.868 U
Xylenes, Total	2.6 U	2.6 U	2.45 U	2.6 U	2.6 U	2.6 U	0.26 U	2.6 U
Naphthalene	2.62 U	2.62 U	2.46 U	2.62 U	2.62 U	2.62 U	0.26 U	2.62 U
Petroleum Hydrocarbons by MA APH								
C5-C8 Aliphatics, Adjusted	120 U	120 U	110 U	120 U	120 U	120 U	13	120 U
C9-C12 Aliphatics, Adjusted	140 U	140 U	130 U	140 U	140 U	140 U	18 U	140 U
C9-C10 Aromatics	100 U	100 U	94 U	100 U	100 U	100 U	10 U	100 U
Volatile Organic Compounds by EPA Method TO-15 (SIM)								
1,1,1-Trichloroethane	265	85.8	67.8	1050	313	373	0.812	48.1
1,1,2-Trichloroethane	1.09 U	1.09 U	1.02 U	1.09 U	1.09 U	1.09 U	0.109 U	1.09 U
1,1-Dichloroethane	1.54	1.38	1.06	3.64	7.84	9.22	0.081 U	15.8
1,1-Dichloroethene	0.792 U	0.792 U	0.745 U	6.02	2.02	2.1	0.079 U	0.792 U
1,2,4-Trimethylbenzene	0.982 U	0.982 U	0.924 U	0.982 U	0.982 U	0.982 U	0.098 U	0.982 U
1,2-Dibromoethane	0.768 U	0.768 U	0.722 U	0.768 U	0.768 U	0.768 U	0.077 U	0.768 U
1,2-Dichloroethane	0.809 U	0.809 U	0.761 U	0.809 U	0.809 U	0.809 U	0.081 U	0.809 U
1,2-Dichloropropane	0.924 U	0.924 U	0.868 U	0.924 U	0.924 U	0.924 U	0.092 U	0.924 U
1,3-Dichlorobenzene	1.2 U	1.2 U	1.13 U	1.2 U	1.2 U	1.2 U	0.12 U	1.2 U
1,4-Dichlorobenzene	1.2 U	1.2 U	1.13 U	1.2 U	1.2 U	1.2 U	0.12 U	1.2 U
Bromodichloromethane	0.67 U	0.67 U	0.63 U	0.67 U	0.67 U	0.67 U	0.067 U	0.67 U
Bromoform	2.06 U	2.06 U	1.94 U	2.06 U	2.06 U	2.06 U	0.206 U	2.06 U
Carbon tetrachloride	1.26 U	1.26 U	1.18 U	1.26 U	1.26 U	1.26 U	0.314	1.26 U
Chlorobenzene	0.92 U	0.92 U	0.865 U	0.92 U	1.38	1.93	0.092 U	0.92 U
Chloroform	9.02	1.46	1.79	0.976 U	13.3	16	0.098 U	3.8
cis-1,2-Dichloroethene	0.792 U	248	194	1.19	5.66	6.7	0.079 U	45.5
Isopropylbenzene	24.6 U	24.6 U	23.1 U	24.6 U	24.6 U	24.6 U	2.46 U	24.6 U
Methylene chloride	17.4 U	17.4 U	16.3 U	17.4 U	17.4 U	17.4 U	1.74 U	17.4 U
Tetrachloroethene	214000	25500	22600	16000	196000	156000	735	9160
trans-1,2-Dichloroethene	0.792 U	1.82	1.38	0.792 U	0.951	1.03	0.079 U	1.19
trans-1,3-Dichloropropene	0.907 UJ	0.907 UJ	0.853 UJ	0.907 UJ	0.907 UJ	0.907 UJ	0.091 UJ	0.907 UJ
Trichloroethene	14.6	569	449	26.2	118	148	0.107 U	168
Vinyl chloride	0.511 U	0.511 U	0.48 U	0.511 U	0.511 U	0.511 U	0.051 U	0.511 U

NOTE:

All concentrations reported in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

ABBREVIATIONS:

U = Compound not detected above presented reporting limit

UJ = Compound not detected; approximate reporting limit presented

J = Compound detected below reporting limit; estimated concentration presented

APH = Massachusetts Air-Phase Petroleum Hydrocarbons Method

TO-15-SIM = Modified EPA Method TO-15 (Selected Ion Monitoring)

Table 4
Analytical Results for Sub-Slab Vapor Samples
February 2011
UniFirst Property
Woburn, MA

Parameter	SV-01	SV-02	SV-03	SV-04	SV-05	SV-06	SV-07	SV-08	SV-09
	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011
Petroleum Hydrocarbons by EPA Method TO-15 (SIM)									
1,3-Butadiene	0.044 U	0.044 U	0.044 U	0.044 U	0.648 U	0.72 U	0.692 U	0.044 U	0.316 U
Methyl tert butyl ether	0.072 U	0.072 U	0.072 U	0.072 U	1.06 U	1.17 U	1.13 U	0.072 U	0.516 U
Benzene	0.223 U	0.223 U	0.223 U	0.223 U	3.28 U	3.64 U	3.5 U	0.223 U	1.6 U
Toluene	0.188 U	0.188 U	0.26	0.576	2.76 U	3.07 U	2.95 U	0.188 U	1.35 U
Ethylbenzene	0.087 U	0.087 U	0.134	0.338	1.27 U	1.41 U	1.36 U	0.087 U	0.621 U
Xylenes (total)	0.26 U	0.26 U	1.05	1.13	3.82 U	4.24 U	4.08 U	0.26 U	1.86 U
Naphthalene	0.168 UJ	0.571 J	0.262 UJ	0.262 UJ	3.84 UJ	4.27 UJ	4.1 UJ	0.262 UJ	1.87 UJ
Petroleum Hydrocarbons by MA APH									
C5-C8 Aliphatics, Adjusted	19 U	12 U	12 U	31 U	180 U	190 U	190 U	20 U	86 U
C9-C10 Aromatics	10 U	10 U	10 U	10 U	150 U	160 U	160 U	10 U	72 U
C9-C12 Aliphatics, Adjusted	240	60	42	160	210 U	220 U	220 U	49	100 U
Volatile Organic Compounds by EPA Method TO-15 (SIM)									
1,1,1-Trichloroethane	0.229	0.665	0.676	5.15	813	2090	298	4.4	30.3
1,1,2-Trichloroethane	0.109 U	0.109 U	0.109 U	0.109 U	1.6 U	1.78 U	1.71 U	0.109 U	0.78 U
1,1-Dichloroethane	0.081 U	0.081 U	0.081 U	0.081 U	1.18 U	1.32 U	3.74	0.081 U	0.579 U
1,1-Dichloroethene	0.079 U	0.079 U	0.079 U	0.079 U	1.16 U	1.29 U	1.24 U	0.079 U	0.567 U
1,2,4-Trimethylbenzene	0.098 U	0.098 U	0.098 U	0.098 U	1.44 U	1.6 U	1.54 U	0.098 U	0.703 U
1,2-Dibromoethane	0.154 U	0.154 U	0.154 U	0.154 U	2.25 U	2.5 U	2.4 U	0.154 U	1.1 U
1,2-Dichloroethane	0.081 U	0.081 U	0.081 U	0.081 U	1.18 U	1.32 U	1.27 U	0.081 U	0.579 U
1,2-Dichloropropane	0.092 U	0.092 U	0.092 U	0.092 U	1.35 U	1.5 U	1.45 U	0.092 U	0.661 U
1,3-Dichlorobenzene	0.12 U	0.12 U	0.12 U	0.12 U	1.76 U	1.96 U	1.88 U	0.12 U	0.86 U
1,4-Dichlorobenzene	0.12 U	0.12 U	0.12 U	0.12 U	1.76 U	1.96 U	1.88 U	0.12 U	0.86 U
Bromodichloromethane	0.134 U	0.134 U	0.134 U	0.134 U	1.96 U	2.18 U	2.1 U	0.134 U	0.958 U
Bromoform	0.206 U	0.206 U	0.206 U	0.206 U	3.03 U	3.36 U	3.23 U	0.206 U	1.48 U
Carbon tetrachloride	0.126 U	0.151	0.126 U	0.201	1.84 U	2.05 U	1.97 U	0.32	0.9 U
Chlorobenzene	0.092 U	0.092 U	0.092 U	0.092 U	1.35 U	1.5 U	1.44 U	0.092 U	0.658 U
Chloroform	0.546	0.195	0.098 U	0.098 U	1.43 U	18	2.75	8.88	0.698 U
cis-1,2-Dichloroethene	0.079 U	0.079 U	0.079 U	0.079 U	1.16 U	1.29 U	1.24 U	0.079 U	0.567 U
Isopropylbenzene	2.46 U	2.46 U	2.46 U	2.46 U	36 U	40 U	38.4 U	2.46 U	17.6 U
Methylene chloride	1.74 U	1.74 U	1.74 U	1.78	25.4 U	28.3 U	27.2 U	1.74 U	12.4 U
Tetrachloroethene	38.6	689	143	104	168000	452000	134000	4640	15200
trans-1,2-Dichloroethene	0.079 U	0.079 U	0.079 U	0.079 U	1.16 U	1.29 U	1.24 U	0.079 U	0.567 U
trans-1,3-Dichloropropene	0.091 U	0.091 U	0.091 U	0.091 U	1.33 U	1.48 U	1.42 U	0.091 U	0.649 U
Trichloroethene	0.107 U	0.107 U	0.107 U	0.107 U	5.43	612	14.4	0.29	3.92
Vinyl chloride	0.051 U	0.051 U	0.051 U	0.051 U	0.749 U	0.832 U	0.8 U	0.051 U	0.366 U

NOTE:

All concentrations reported in micrograms per cubic meter (µg/m³).

ABBREVIATIONS:

U = Compound not detected above presented reporting limit

UJ = Compound not detected; approximate reporting limit presented

J = Compound detected below reporting limit; estimated concentration presented

APH = Massachusetts Air-Phase Petroleum Hydrocarbons Method

TO-15-SIM = Modified EPA Method TO-15 (Selected Ion Monitoring)

Table 4
Analytical Results for Sub-Slab Vapor Samples
February 2011
UniFirst Property
Woburn, MA

Parameter	SV-10	SV-10 Duplicate	SV-11	SV-11 Duplicate	SV-12	SV-13	SV-14	SV-15
	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011	2/21/2011
Petroleum Hydrocarbons by EPA Method TO-15 (SIM)								
1,3-Butadiene	0.671 U	0.668 U	0.347 U	0.344 U	0.326 U	0.692 U	0.044 U	0.044 U
Methyl tert butyl ether	1.09 U	1.09 U	0.566 U	0.561 U	0.531 U	1.13 U	0.072 U	0.281
Benzene	3.39 U	3.38 U	1.75 U	1.74 U	1.65 U	3.5 U	0.223 U	0.223 U
Toluene	2.86 U	2.84 U	1.48 U	1.47 U	1.39 U	2.95 U	0.188 U	0.222
Ethylbenzene	1.32 U	1.31 U	0.681 U	0.676 U	0.639 U	1.36 U	0.087 U	0.087 U
Xylenes (total)	3.95 U	3.93 U	2.04 U	2.03 U	1.92 U	4.08 U	0.26 U	0.438
Naphthalene	3.98 UJ	3.96 UJ	2.06 UJ	2.04 UJ	1.93 UJ	4.1 UJ	0.262 UJ	0.236 UJ
Petroleum Hydrocarbons by MA APH								
C5-C8 Aliphatics, Adjusted	180 U	180 U	94 U	94 U	89 U	190 U	13 U	25 U
C9-C10 Aromatics	150 U	150 U	78 U	78 U	74 U	160 U	10 U	10 U
C9-C12 Aliphatics, Adjusted	210 U	210 U	110 U	110 U	110	220 U	45	68
Volatile Organic Compounds by EPA Method TO-15 (SIM)								
1,1,1-Trichloroethane	291	272	164	150	251	384	1.55	130
1,1,2-Trichloroethane	1.66 U	1.65 U	0.856 U	0.849 U	0.803 U	1.71 U	0.109 U	0.109 U
1,1-Dichloroethane	1.23 U	1.22 U	1.68	1.67	1.31	6.02	0.081 U	41.8
1,1-Dichloroethene	1.2 U	1.2 U	0.622 U	0.617 U	1.11	3.54	0.079 U	1.76
1,2,4-Trimethylbenzene	1.49 U	1.48 U	0.771 U	0.765 U	0.724 U	1.54 U	0.098 U	0.236
1,2-Dibromoethane	2.33 U	2.32 U	1.2 U	1.2 U	1.13 U	2.4 U	0.154 U	0.154 U
1,2-Dichloroethane	1.23 U	1.22 U	0.635 U	0.63	0.596 U	1.27 U	0.081 U	0.081 U
1,2-Dichloropropane	1.4 U	1.4 U	0.725 U	0.719 U	0.68 U	1.45 U	0.092 U	0.092 U
1,3-Dichlorobenzene	1.82 U	1.82 U	0.943 U	0.936 U	0.885 U	1.88 U	0.12 U	0.12 U
1,4-Dichlorobenzene	1.82 U	1.82 U	0.943 U	0.936 U	0.885 U	1.88 U	0.12 U	0.12 U
Bromodichloromethane	2.03 U	2.02 U	1.05 U	1.04 U	0.987 U	2.1 U	0.134 U	0.134 U
Bromoform	3.14 U	3.12 U	1.62 U	1.61 U	1.52 U	3.23 U	0.206 U	0.206 U
Carbon tetrachloride	1.91 U	1.9 U	0.987 U	0.979 U	0.926 U	1.97 U	0.295	0.176
Chlorobenzene	1.4 U	1.39 U	0.722 U	0.716 U	0.678 U	1.44 U	0.092 U	0.092 U
Chloroform	9.03	8.84	1.11	1.1	0.719 U	11.1	0.098 U	7.46
cis-1,2-Dichloroethene	1.2 U	1.2 U	297	285	0.584 U	2.3	0.079 U	16.7
Isopropylbenzene	37.3 U	37.1 U	19.3 U	19.1 U	18.1 U	38.4 U	2.46 U	2.46 U
Methylene chloride	26.3 U	26.2 U	13.6 U	13.5 U	12.8 U	27.2 U	1.74 U	1.74 U
Tetrachloroethene	171000	176000	47400	47700	12300	133000	1060	3160
trans-1,2-Dichloroethene	1.2 U	1.2 U	2.02	1.91	0.584 U	1.24 U	0.079 U	0.376
trans-1,3-Dichloropropene	1.38 U	1.37 U	0.712 U	0.706 U	0.668 U	1.42 U	0.091 U	0.091 U
Trichloroethene	11.9	11	765	719	18.2	107	0.107 U	13.8
Vinyl chloride	0.775 U	0.772 U	0.401 U	0.398 U	0.376 U	0.8 U	0.051 U	0.051 U

NOTE:

All concentrations reported in micrograms per cubic meter (µg/m³).

ABBREVIATIONS:

U = Compound not detected above presented reporting limit

UJ = Compound not detected; approximate reporting limit presented

J = Compound detected below reporting limit; estimated concentration presented

APH = Massachusetts Air-Phase Petroleum Hydrocarbons Method

TO-15-SIM = Modified EPA Method TO-15 (Selected Ion Monitoring)

Table 5
VOC Concentrations in Water Table Well Samples
April 2011
UniFirst Property
Woburn, MA

Parameter	S70D	S70S	S71D	UC4	UC5	UC6	UC6S	UC6S Duplicate
1,1,1-Trichloroethane	ND < 1	ND < 1	1	ND < 1	9	ND < 1	ND < 1	ND < 1
1,1,2,2-Tetrachloroethane	ND < 1	NA	ND < 1	NA	NA	ND < 1	NA	NA
1,1,2-Trichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethene	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,2-Dichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1 J	ND < 1 J
Carbon Tetrachloride	ND < 1	ND < 0.050	ND < 1	ND < 0.050	ND < 1	ND < 1 J	ND < 0.10 J	ND < 0.20 J
Chloroethane	ND < 2	NA	ND < 2	NA	NA	ND < 2	NA	NA
Chloroform	ND < 1	ND < 0.10	ND < 1	ND < 0.10	ND < 1	ND < 1	ND < 0.20 J	ND < 0.40 J
cis-1,2-Dichloroethene	ND < 1	ND < 0.050	ND < 1	ND < 0.050	ND < 2 J	2	ND < 0.10 J	ND < 0.20 J
Tetrachloroethene	0.8 J	0.048 J	35 J	ND < 0.050 J	130	28	4 J	3.9 J
trans-1,2-Dichloroethene	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1 J	ND < 1	ND < 1
Trichloroethene	ND < 1	ND < 1	ND < 1 J	0.5 J	4 J	8 J	ND < 1 J	ND < 1 J
Vinyl Chloride	ND < 2	ND < 0.050	ND < 2	ND < 0.050	ND < 1	ND < 2	ND < 0.10 J	ND < 0.20 J

NOTE:

Concentrations reported in micrograms per liter (µg/L).

ABBREVIATIONS:

ND = Not Detected, detection limit provided.

J = Concentration or detection limit is estimated.

NA = Not analyzed.

Table 5
VOC Concentrations in Water Table Well Samples
April 2011
UniFirst Property
Woburn, MA

Parameter	UC10-6	UC10M	UC10S	UC18	UC19	UC19M	UC19S	UC19S
1,1,1-Trichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1,2,2-Tetrachloroethane	ND < 1	ND < 1	NA	NA	ND < 1	ND < 1	ND < 1	NA
1,1,2-Trichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethene	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,2-Dichloroethane	ND < 1 J	ND < 1	ND < 1	ND < 1 J	ND < 1	ND < 1	ND < 1	ND < 1
Carbon Tetrachloride	ND < 1 J	ND < 1	ND < 0.050	ND < 0.050	ND < 1	ND < 1	ND < 1	ND < 0.050
Chloroethane	ND < 2 J	ND < 2	NA	NA	ND < 2	ND < 2	ND < 2	NA
Chloroform	ND < 1	ND < 1	ND < 0.10	ND < 0.10	ND < 1	ND < 1	ND < 1	ND < 0.10
cis-1,2-Dichloroethene	99	ND < 1	ND < 0.050	ND < 0.050	ND < 1	ND < 1	ND < 1	ND < 0.050
Tetrachloroethene	47	ND < 1	ND < 0.050 J	0.09	ND < 1	ND < 1	ND < 1	ND < 0.050 J
trans-1,2-Dichloroethene	1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
Trichloroethene	19 J	ND < 1 J	ND < 1	0.7 J	ND < 1 J	ND < 1 J	ND < 1 J	ND < 1
Vinyl Chloride	ND < 2	ND < 2	ND < 0.050	ND < 0.050	ND < 2	ND < 2	ND < 2	ND < 0.050

NOTE:

Concentrations reported in micrograms per liter (µg/L).

ABBREVIATIONS:

ND = Not Detected, detection limit provided.

J = Concentration or detection limit is estimated.

NA = Not analyzed.

Table 5
VOC Concentrations in Water Table Well Samples
April 2011
UniFirst Property
Woburn, MA

Parameter	UC24S	UC25	UC26S	UC29S	UC31S
1,1,1-Trichloroethane	ND < 1	1 J	ND < 1	ND < 1	ND < 1
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,1-Dichloroethene	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
1,2-Dichloroethane	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
Carbon Tetrachloride	ND < 0.050	ND < 1	ND < 0.10	ND < 1	ND < 0.050
Chloroethane	NA	NA	NA	NA	NA
Chloroform	ND < 0.10	ND < 1	ND < 0.20	ND < 1	ND < 0.10
cis-1,2-Dichloroethene	ND < 0.050	ND < 1	ND < 0.10	3	ND < 0.050
Tetrachloroethene	ND < 0.050 J	110	6	150	ND < 0.050 J
trans-1,2-Dichloroethene	ND < 1	ND < 1	ND < 1	ND < 1	ND < 1
Trichloroethene	ND < 1	0.5 J	ND < 1	2 J	ND < 1
Vinyl Chloride	ND < 0.050	ND < 1	ND < 0.10	ND < 1	ND < 0.050

NOTE:

Concentrations reported in micrograms per liter (µg/L).

ABBREVIATIONS:

ND = Not Detected, detection limit provided.

J = Concentration or detection limit is estimated.

NA = Not analyzed.

Table 6
Anticipated Step Test Vacuums and Durations
UniFirst Property
Woburn, MA

Test Point	Test Location Rationale	Step	Proposed Applied Vacuum ¹ ("H ₂ O)	Anticipated Step Duration (minutes)
Vapor Extraction Test Point SVE-1	within the "waste oil contamination" area outside Building B footprint near asphalt to soil cover transition	1	10	up to 120
		2	20	up to 120
		3	30	up to 120
		4	40	up to 120
		5	> 50 ²	up to 120
Vapor Extraction Test Point SVE-2	within the area of VOC-impacted soil highest observed VOC impact to soil and groundwater within the modified Building B footprint (former loading dock area)	1	10	up to 120
		2	20	up to 120
		3	30	up to 120
		4	40	up to 120
		5	> 50	up to 120
Vapor Extraction Test Point SVE-3	within the area of VOC-impacted soil highest observed VOC impact to sub-slab vapor near the former "gutter"	1	10	up to 120
		2	20	up to 120
		3	30	up to 120
		4	40	up to 120
		5	> 50	up to 120
Vapor Extraction Test Point SVE-4	within the area of VOC-impacted soil high PCE concentration in shallow soil sample from UC35 within the original Building B footprint	1	10	up to 120
		2	20	up to 120
		3	30	up to 120
		4	40	up to 120
		5	> 50	up to 120
Sub-Slab Vapor Extraction Test Point SSVE-1	outside the area of VOC-impacted soil nearby SV-07 location showed sub-slab vapor impact evaluate ROI under Building B slab	1	1	up to 120
		2	2	up to 120
		3	4	up to 120
Sub-Slab Vapor Extraction Test Point SSVE-2	outside the area of VOC-impacted soil nearby SV-09 location showed sub-slab vapor impact evaluate ROI under Building C slab	1	1	up to 120
		2	2	up to 120
		3	4	up to 120

NOTES:

1. Higher vacuum step(s) will not be conducted at locations where groundwater upwelling and decreased air flow are observed at previous step(s).
2. Higher vacuum step(s) may be conducted at locations where groundwater upwelling and decreased air flow have not been observed at 40 "H₂O.

ABBREVIATION:

"H₂O = inches of water

Table 7
Anticipated Constant Rate Test Measurements and Frequency
UniFirst Property
Woburn, MA

Location	Measurement	Rationale	Measurement Method	Minimum Measurement Frequency
SVE Pilot Test Points	Vacuum ("H ₂ O)	Monitor applied vacuum and estimate potential VOC mass removal rate	Pressure gauge or manometer	Before starting blower operation; after 1 hour, 2 hours, 4 hours, and 8 hours of operation; daily thereafter; and immediately prior to shutdown.
	Velocity (ft/min)		Velocity meter	After 1 hour, 2 hours, 4 hours, and 8 hours of operation; daily thereafter; and immediately prior to shutdown.
	Temperature (°F)		Digital thermometer	After 1 hour, 2 hours, 4 hours, and 8 hours of operation; daily thereafter; and immediately prior to shutdown.
	Water level (ft bgs/ft bts)	Evaluate potential vacuum-induced groundwater mounding	In-well pressure transducers	Approximately 5-minute increments.
	Total VOC Concentration (ppmv)	Monitor total VOC concentration in extracted soil vapor	PID ¹	After 1 hour, 2 hours, 4 hours, and 8 hours of operation; daily thereafter; and immediately prior to shutdown.
	VOCs (µg/m ³)	Collect three samples during each constant rate test to resolve the anticipated non-linear concentration response curve; estimate potential VOC mass removal rate	Laboratory (EPA Method TO-15)	Within 2 hours of startup; approximately mid-test; and immediately prior to shutdown.
SVM Points	Vacuum ("H ₂ O)	Estimate ROI	Pressure gauge or manometer	Before starting blower operation; approximately hourly for the first 4 hours and after 8 hours of operation; at least twice daily thereafter; and immediately prior to shutdown.
Select Groundwater Monitoring Wells				
Existing SV Points				
Off-Gas Treatment Influent	Total VOC Concentration (ppmv)	MassDEP policy compliance	PID ¹	Each day of operation.
Off-Gas Treatment Effluent	Total VOC Concentration (ppmv)	MassDEP policy compliance	PID ¹	Each day of operation.

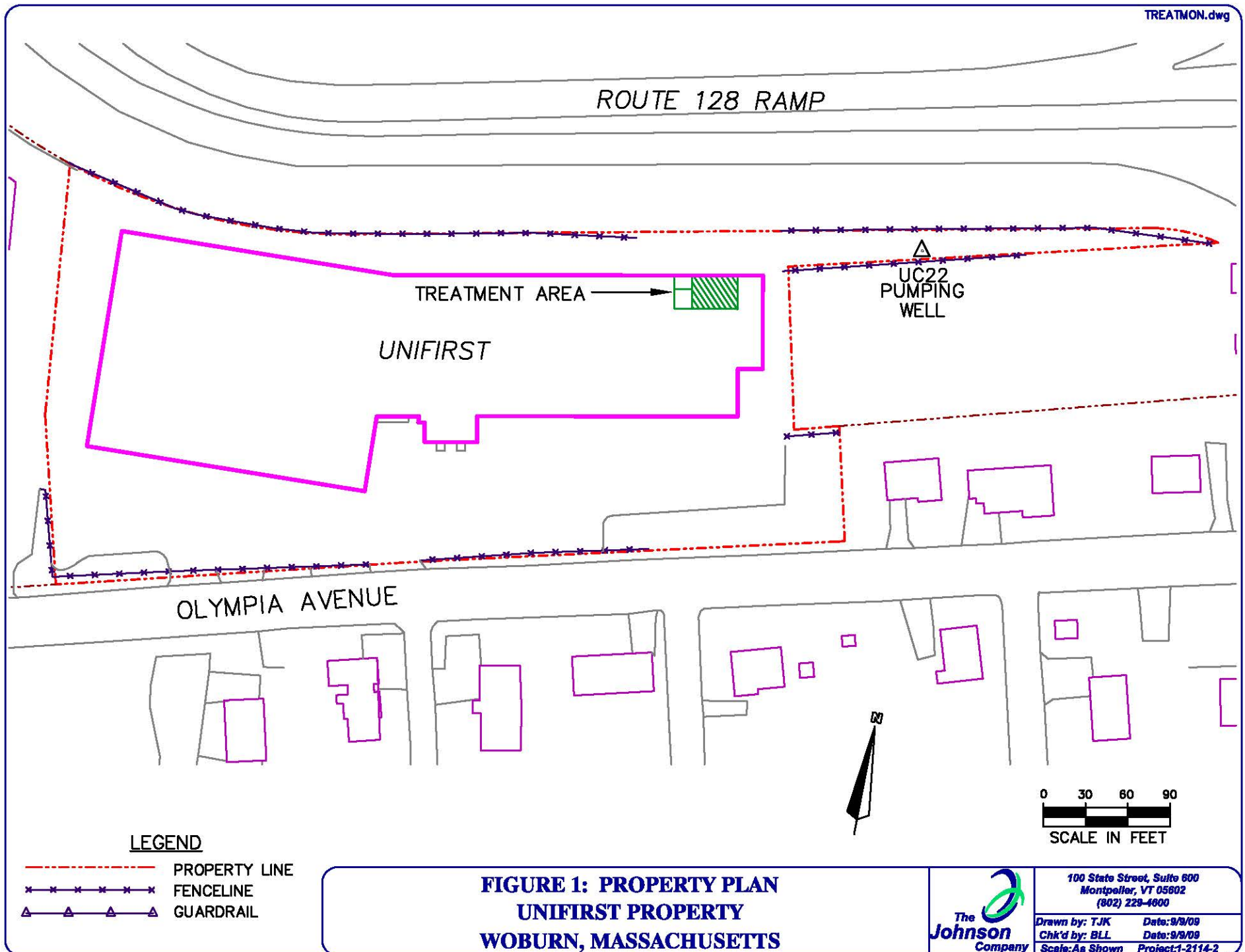
ABBREVIATIONS:

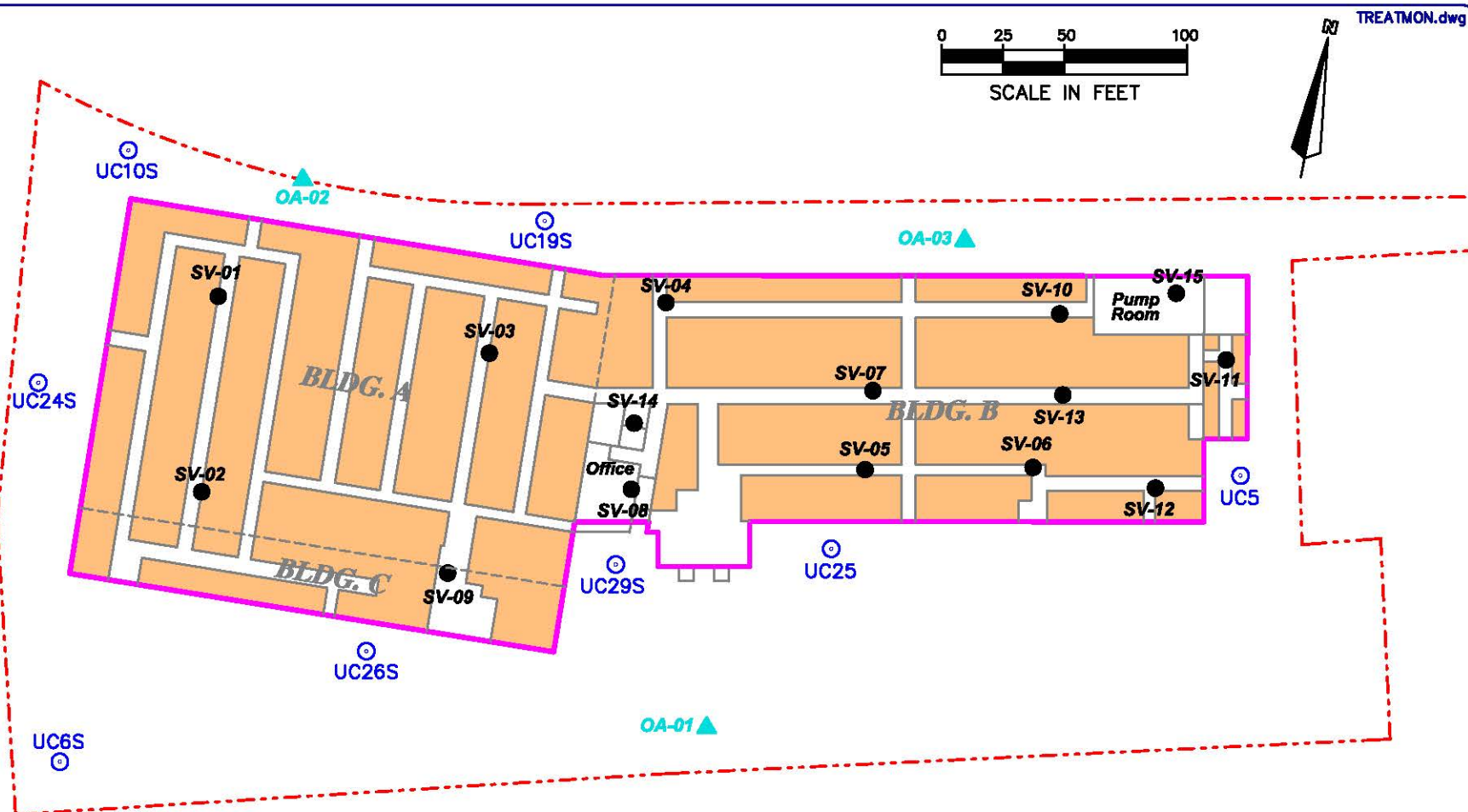
"H₂O = inches of water
ft/min = feet per minute
ft bgs = feet below ground surface
ft bts = feet below top of floor slab
°F = degrees Fahrenheit
µg/m³ = micrograms per cubic meter
MassDEP = Massachusetts Department of Environmental Protection
PID = photo ionization detector
ppmv = parts per million by volume
ROI = radius of influence

NOTE:

1. The PID will be calibrated at least once daily, more often if response is slow. Calibration will be checked twice daily (midday and at the end of the day). The PID will be recalibrated if the calibration checks indicate a significant variation from the standard. The PID will be replaced if it cannot be recalibrated consistent with the SOP provided with the attached QAPP

FIGURES





LEGEND

- SV-01 ● CO-LOCATED SUB-SLAB VAPOR /
INDOOR AIR SAMPLING LOCATION
- OA-01 ▲ OUTDOOR AIR SAMPLING LOCATION
- UC6S ⊙ WATER-TABLE MONITORING WELL LOCATION

— BUILDING FOOTPRINT

- - - PROPERTY BOUNDARY

APPROXIMATE STORAGE AREA FOOTPRINT

SOURCE:

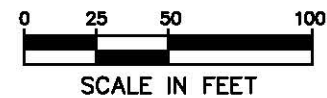
1. UNDATED LAYOUT DRAWING OF THE EXTRA SPACE
STORAGE OPERATION PROVIDED TO UNIFIRST CORP.

**FIGURE 2: CURRENT BUILDING LAYOUT AND
2010 - 2011 IAQA/VI SAMPLING LOCATIONS
UNIFIRST PROPERTY, WOBURN, MASSACHUSETTS**

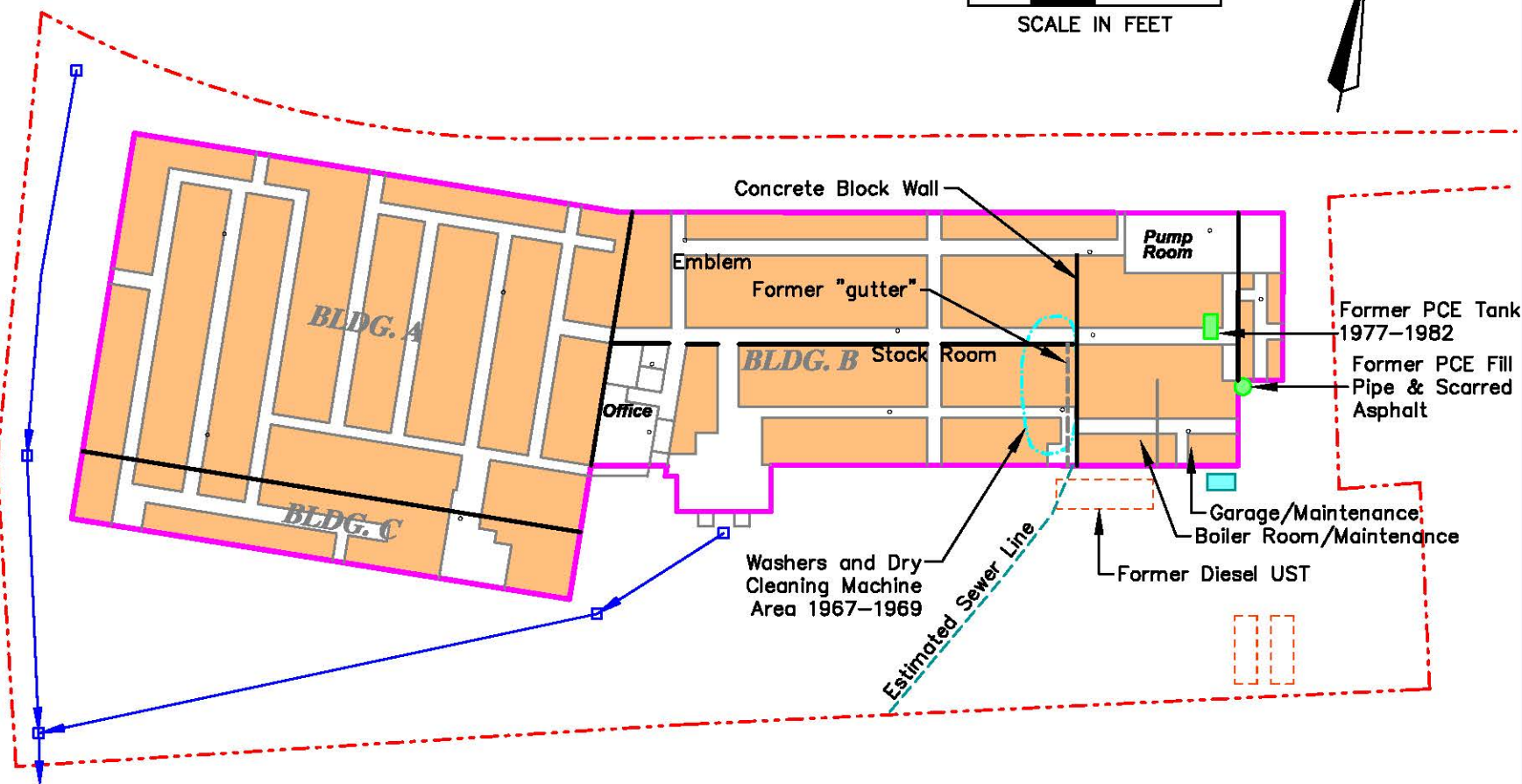


100 State Street, Suite 600
Montpelier, VT 05602
(802) 229-4600

Drawn by: TJK Date: 03/29/11
Chk'd by: BLL Date: 03/29/11
Scale: As Shown Project: 1-2114-2



TREATMON.dwg



LEGEND

- STORMWATER DRAIN W/CATCH BASIN
- INTERIOR WALL LOCATION (MAY INDICATE PRESENCE OF SUB-SLAB FOOTING)
- BUILDING FOOTPRINT
- PROPERTY BOUNDARY
- APPROXIMATE STORAGE AREA FOOTPRINT
- FORMER DUMPSTER LOCATION

NOTE:

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

SOURCE:

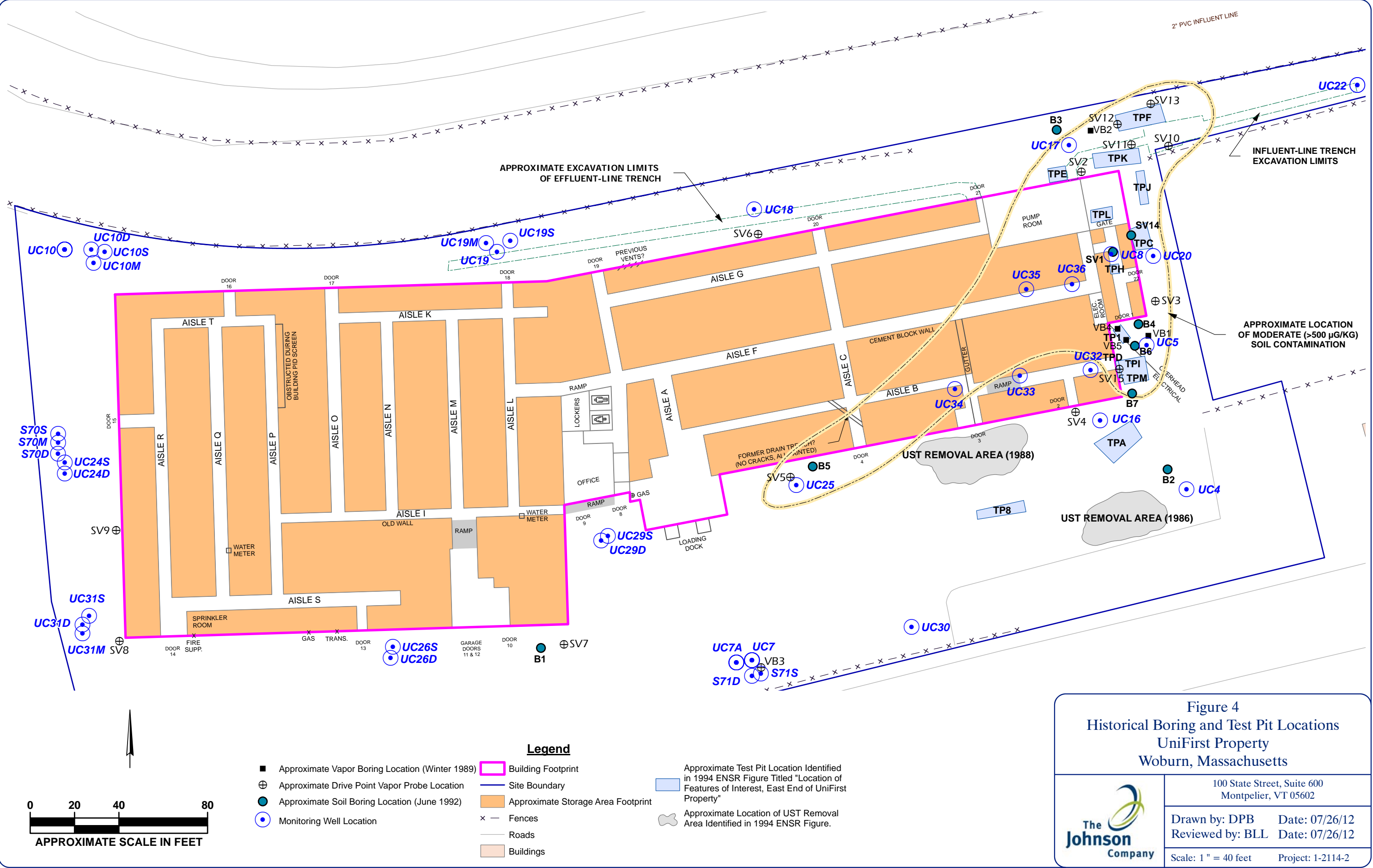
1. UNDATED LAYOUT DRAWING OF THE EXTRA SPACE STORAGE OPERATION PROVIDED TO UNIFIRST CORP.

**FIGURE 3: APPROXIMATE LOCATIONS
OF FORMER OPERATIONS FEATURES
UNIFIRST PROPERTY, WOBURN, MASSACHUSETTS**



100 State Street, Suite 600
Montpelier, VT 05602
(802) 229-4600

Drawn by: TJK Date: 04/19/11
Chk'd by: BLL Date: 04/28/11
Scale: As Shown Project: 1-2114-2



Unconsolidated Deposits Impact
from Shallow Groundwater
September 1992

Figure 5

UNIFIRST CORPORATION

OLYMPIA AVENUE

EXPLANATION

0.85 AVERAGED TETRACHLOROETHENE CONCENTRATION (PPMV)

⊗ DRIVE POINT VAPOR PROBE LOCATION

■ VAPOR BORING

- NOTES: 1) LOCATIONS FROM A SURVEY BY BSC GROUP OF BOSTON, MA.
2) WELL TYPES FROM DRAWINGS BY ENSR CONSULTING & ENGINEERING
3) BASE MAP PRODUCED BY GEOTRANS, INC OF HARVARD, MA
FROM AERIAL SURVEY BY COL-EAST, INC. OF NORTH ADAMS, MA.
4) SOIL-GAS CONTOURS IN CONCENTRATION IN (ppmv)

0 75 150
SCALE IN FEET

FIGURE 3-4

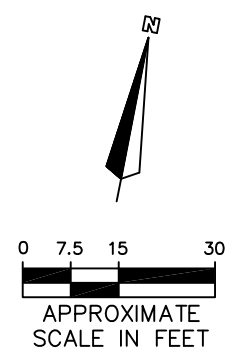
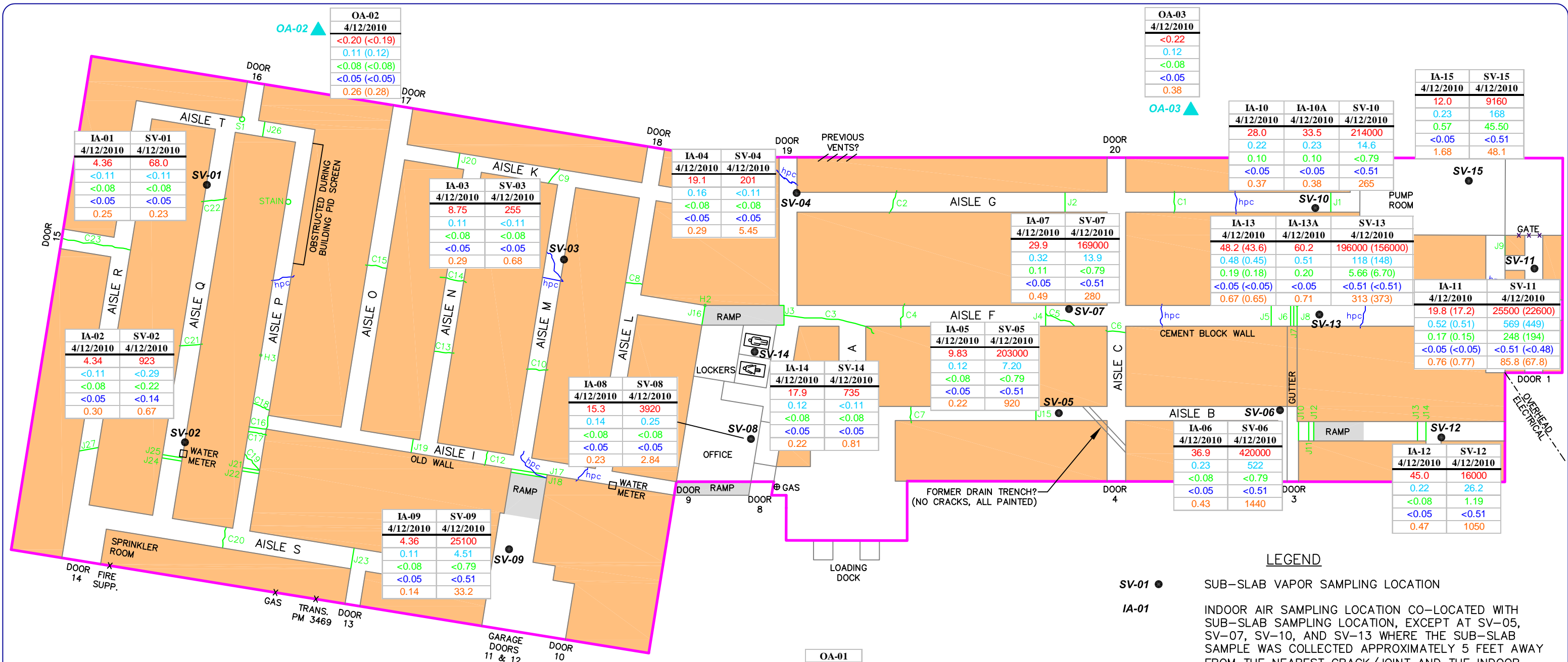
REV. 3-11/11/92 UD-MAP 15 BY:FD

ENSR

ENSR CONSULTING & ENGINEERING

SHALLOW SOIL VAPOR PCE
CONCENTRATIONS SEPTEMBER 1992
UNIFIRST PROPERTY

DRAWN BY:	DATE:	PROJECT NO.
M.D.F.	8/94	3140-023




KEY	
IA-01	Location
4/12/2010	Sampling Date
4.36	PCE Concentration (ug/m3)
<0.11	TCE Concentration (ug/m3)
<0.08	c12DCE Concentration (ug/m3)
<0.05	VC Concentration (ug/m3)
0.25	111TCA Concentration (ug/m3)
(Duplicate values shown in parentheses)	
Abbr.	Description
PCE	Tetrachloroethene
TCE	Trichloroethene
c12DCE	cis-1,2-Dichloroethene
VC	Vinyl chloride
111TCA	1,1,1-Trichloroethane

NOTES:

1. BASED ON AN UNDATED LAYOUT DRAWING OF THE EXTRA SPACE STORAGE OPERATION PROVIDED TO UNIFIRST CORP.
2. ALL LOCATIONS ARE APPROXIMATE.

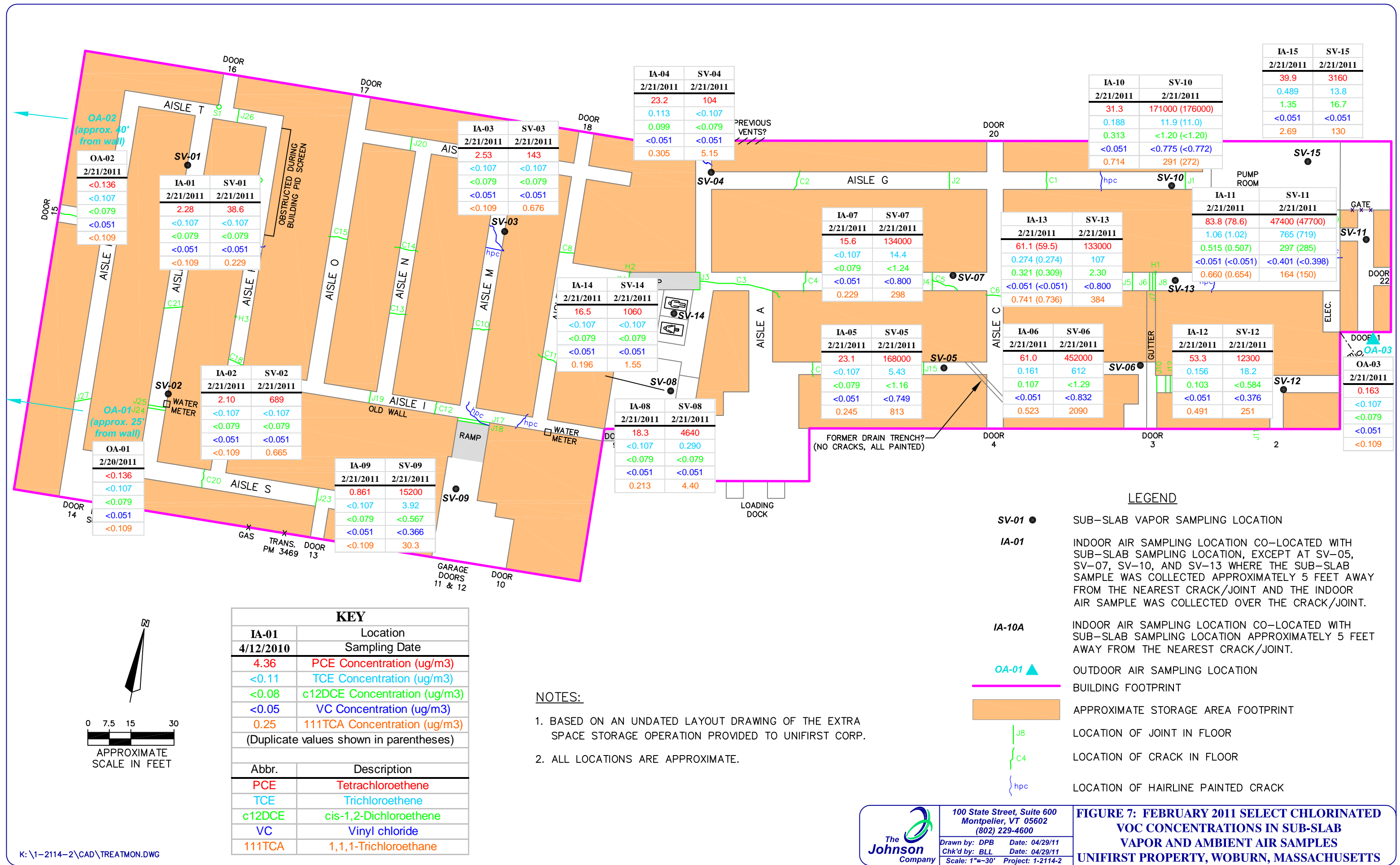
LEGEND	
SV-01 ●	SUB-SLAB VAPOR SAMPLING LOCATION
IA-01	INDOOR AIR SAMPLING LOCATION CO-LOCATED WITH SUB-SLAB SAMPLING LOCATION, EXCEPT AT SV-05, SV-07, SV-10, AND SV-13 WHERE THE SUB-SLAB SAMPLE WAS COLLECTED APPROXIMATELY 5 FEET AWAY FROM THE NEAREST CRACK/JOINT AND THE INDOOR AIR SAMPLE WAS COLLECTED OVER THE CRACK/JOINT.
IA-10A	INDOOR AIR SAMPLING LOCATION CO-LOCATED WITH SUB-SLAB SAMPLING LOCATION APPROXIMATELY 5 FEET AWAY FROM THE NEAREST CRACK/JOINT.
OA-01 ▲	OUTDOOR AIR SAMPLING LOCATION
[Orange Outline]	BUILDING FOOTPRINT
[Orange Fill]	APPROXIMATE STORAGE AREA FOOTPRINT
J8	LOCATION OF JOINT IN FLOOR
C4	LOCATION OF CRACK IN FLOOR
hpc	LOCATION OF HAIRLINE PAINTED CRACK

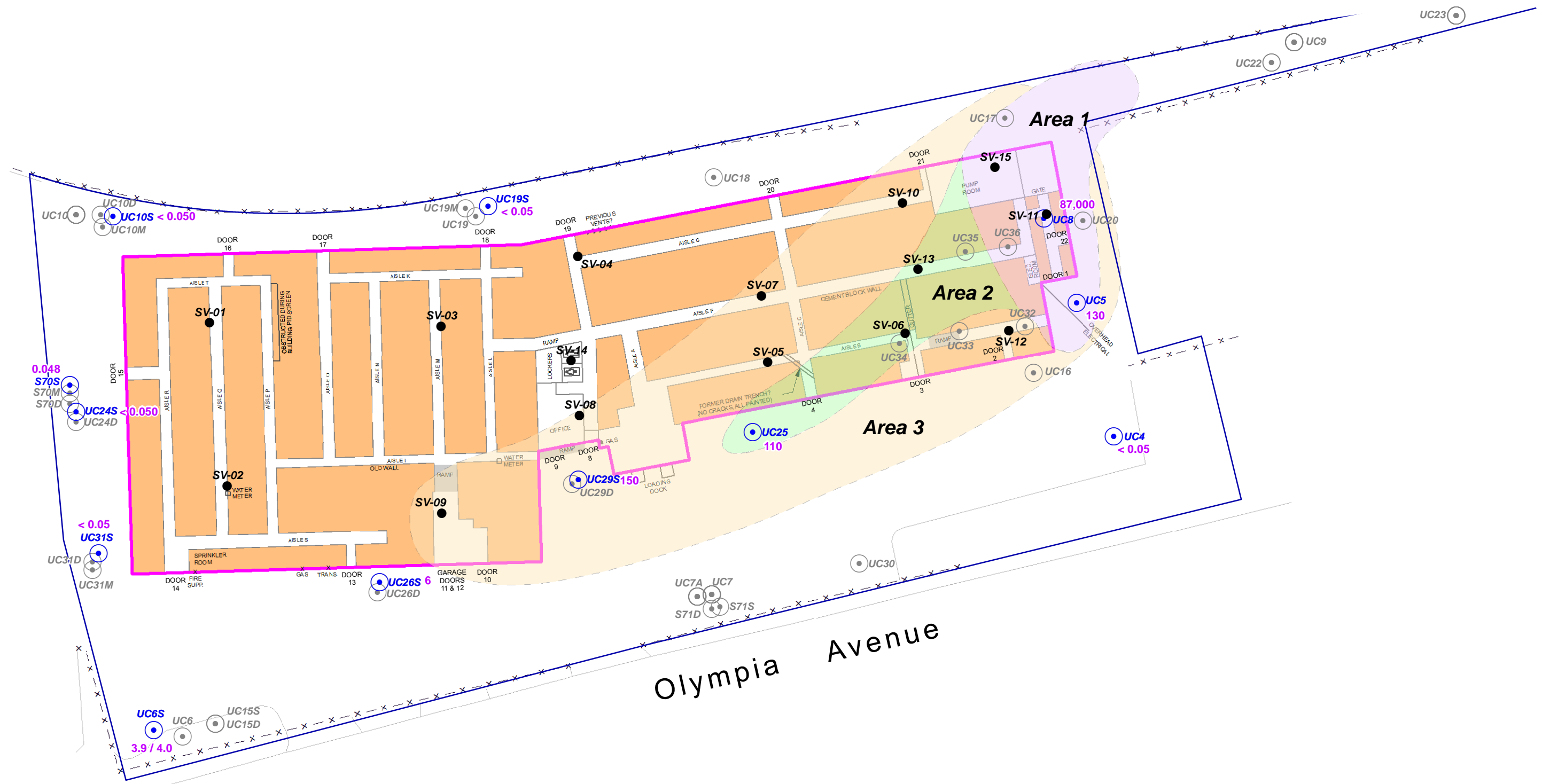


100 State Street, Suite 600
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(802) 229-4600




Drawn by: TJK Date: 06/15/10
Chk'd by: BLL Date: 06/15/10
Scale: 1"=30' Project: 1-2114-2

FIGURE 6: APRIL 2010 SELECT CHLORINATED
VOC CONCENTRATIONS IN SUB-SLAB
VAPOR AND AMBIENT AIR SAMPLES
UNIFIRST PROPERTY, WOBURN, MASSACHUSETTS





Area 1: Most-Impacted Soil ("Source Area")
 Area 2: Impacted Soil (> 500 µg/kg in 1994 Report)
 Area 3: Impacted Groundwater at Concentrations > 87 µg/L - Elevated Subslab and Likely Soil Vapor Concentrations

- × — Fence
- Edge of Roadway
-  Building
-  Building Footprint
- Site Boundary
-  Approximate Storage Area Footprint

Area 1: Most-Impacted Soil ("Source Area")
 Area 2: Impacted Soil (> 500 µg/kg in 1994 Report)
 Area 3: Impacted Groundwater at Concentrations > 87 µg/L - Elevated Subslab and Likely Soil Vapor Concentrations



The
Johnson
Company

100 State Street, Suite 600 Montpelier, VT 05602	
Drawn by: DPB	Date: 07/09/12
Reviewed by: BLL	Date: 07/26/12
Scale: 1" = 50 feet	Project: 1-2114-2

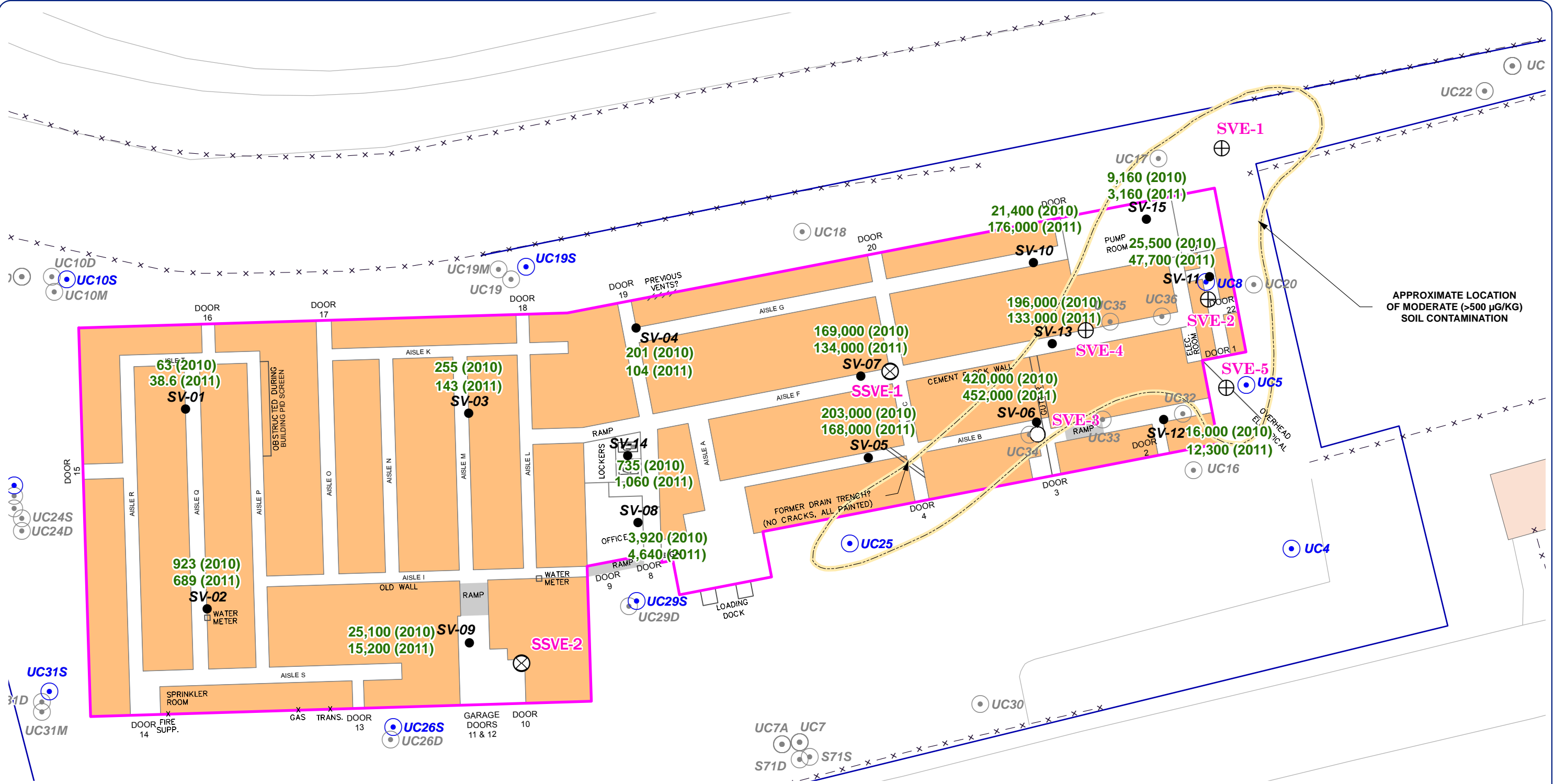


Figure 9
SVE Pilot Test Point Locations
UniFirst Property
Woburn, Massachusetts

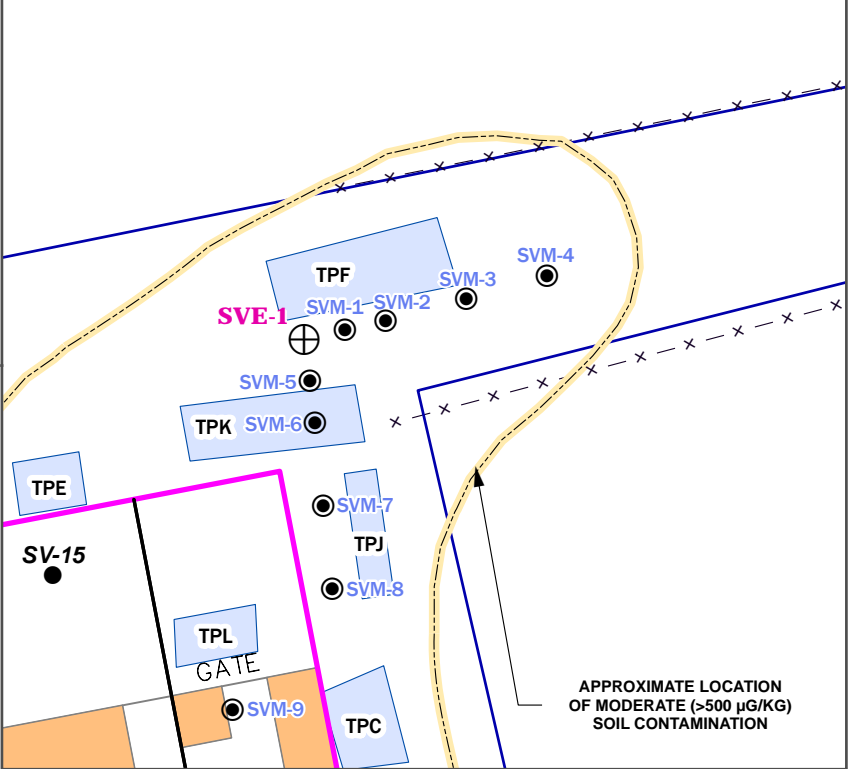


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Montpelier, VT 05602

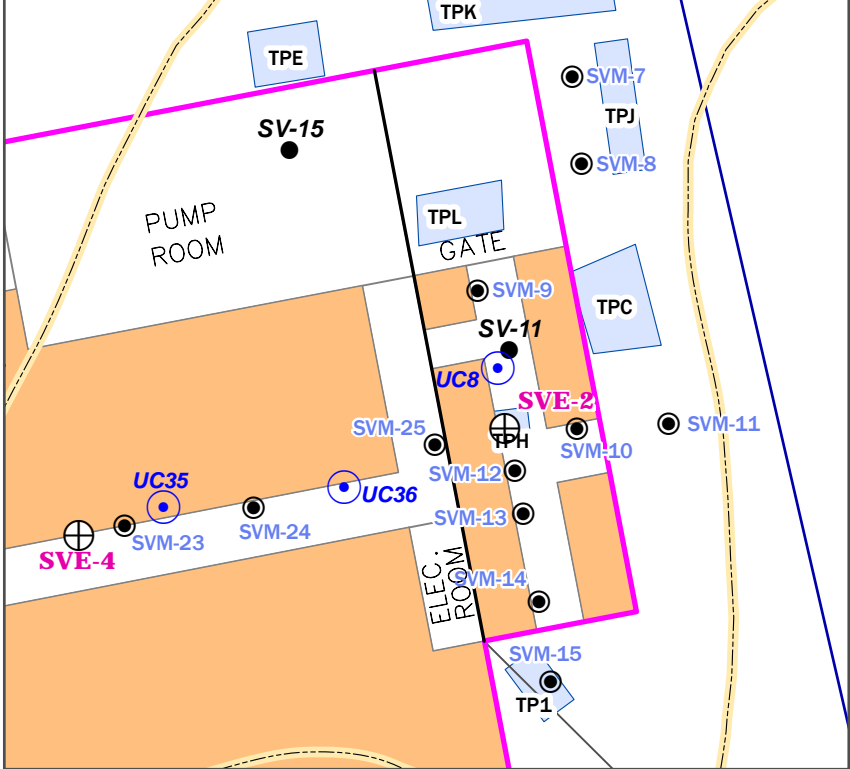
Drawn by: DPB Date: 07/26/12
Reviewed by: BLL Date: 07/26/12

Scale: 1" = 40 feet Project: 1-2114-2

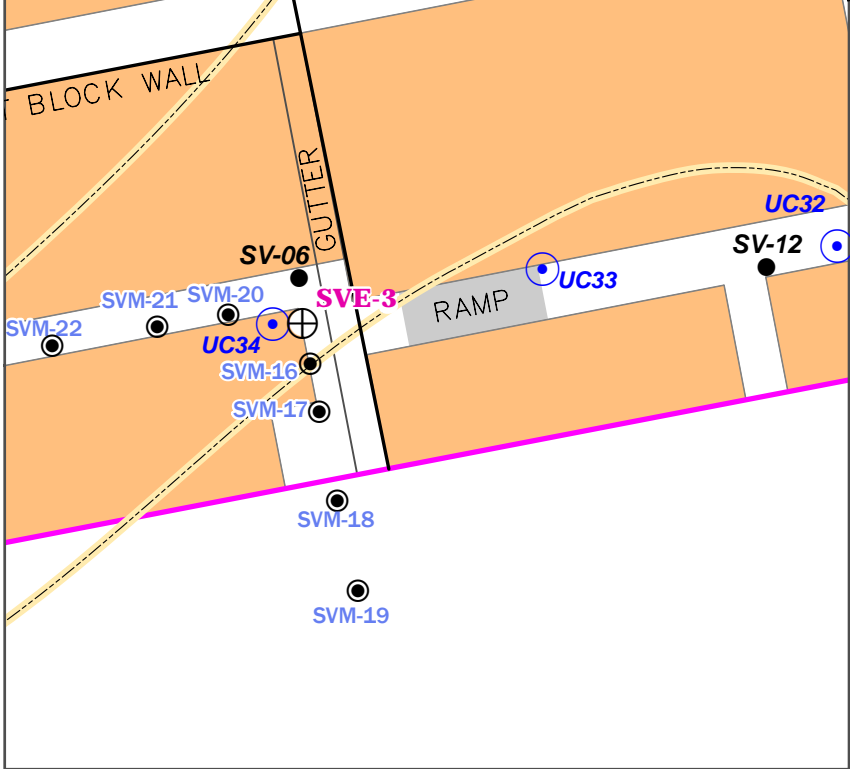
SVE-1 Test Point and Observation Points Detail



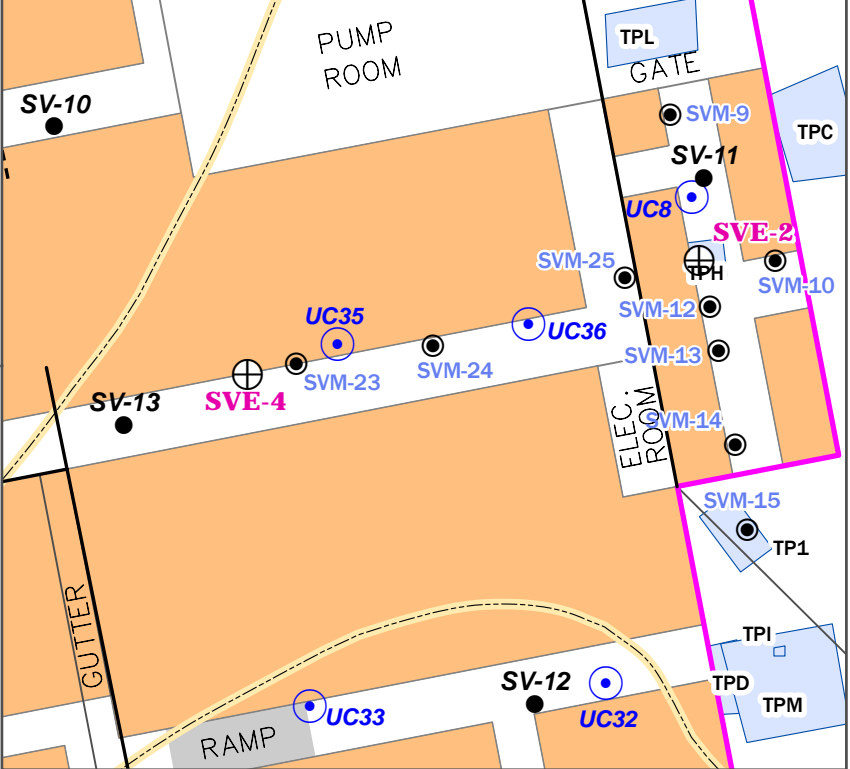
SVE-2 Test Point and Observation Points Detail



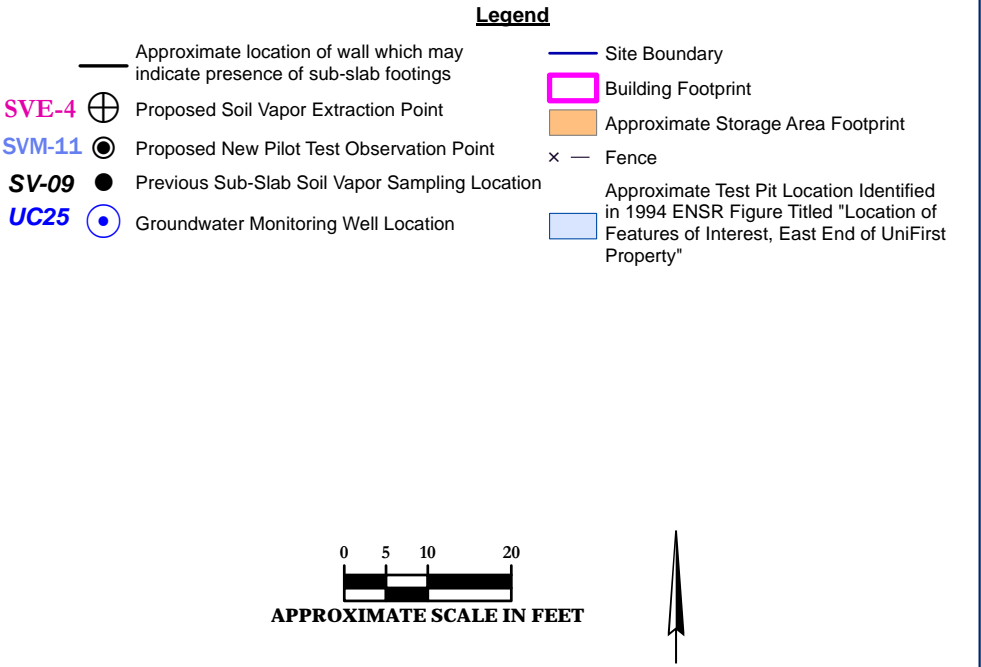
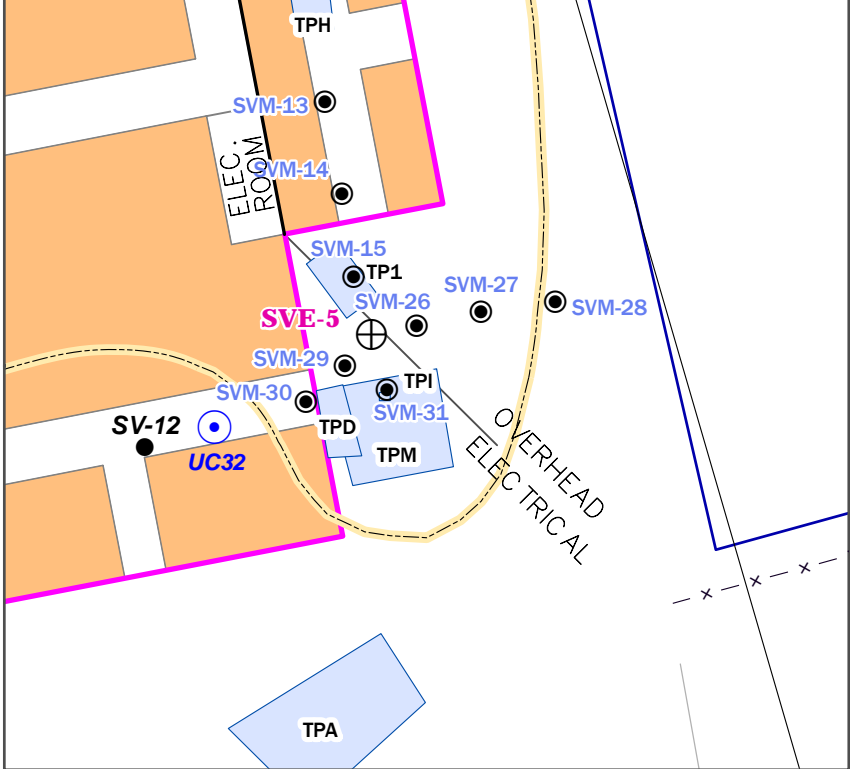
SVE-3 Test Point and Observation Points Detail

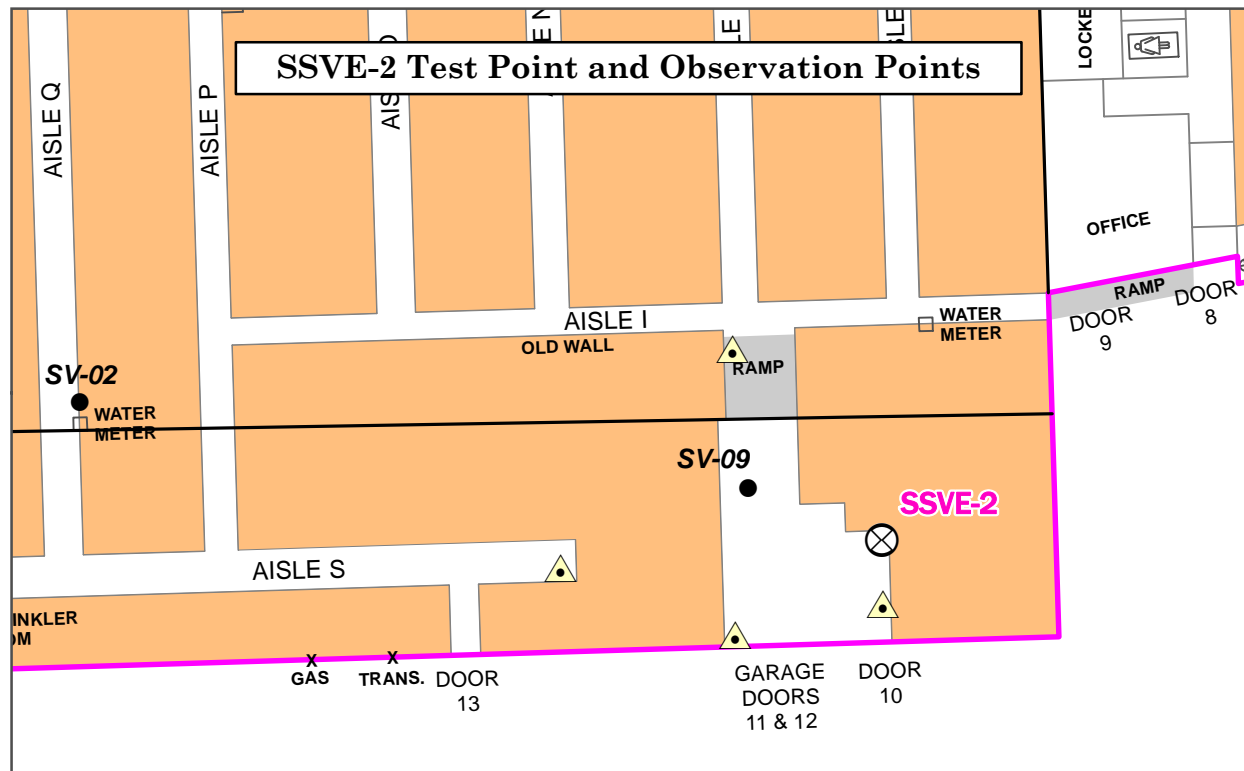


SVE-4 Test Point and Observation Points Detail



SVE-5 Test Point and Observation Points Detail





0 15 30

APPROXIMATE SCALE IN FEET

FIGURE 11: SSVE POINT
AND OBSERVATION POINTS LOCATIONS
UNIFIRST PROPERTY: WOBURN, MASSACHUSETTS

APPENDIX A

SCHEMATIC CONSTRUCTION DIAGRAMS



Drawn by: CFF	Date: 03/28/11
Chk'd by: BLL	Date: 03/29/11
Scale: Not to Scale	Project: 1-2114-2

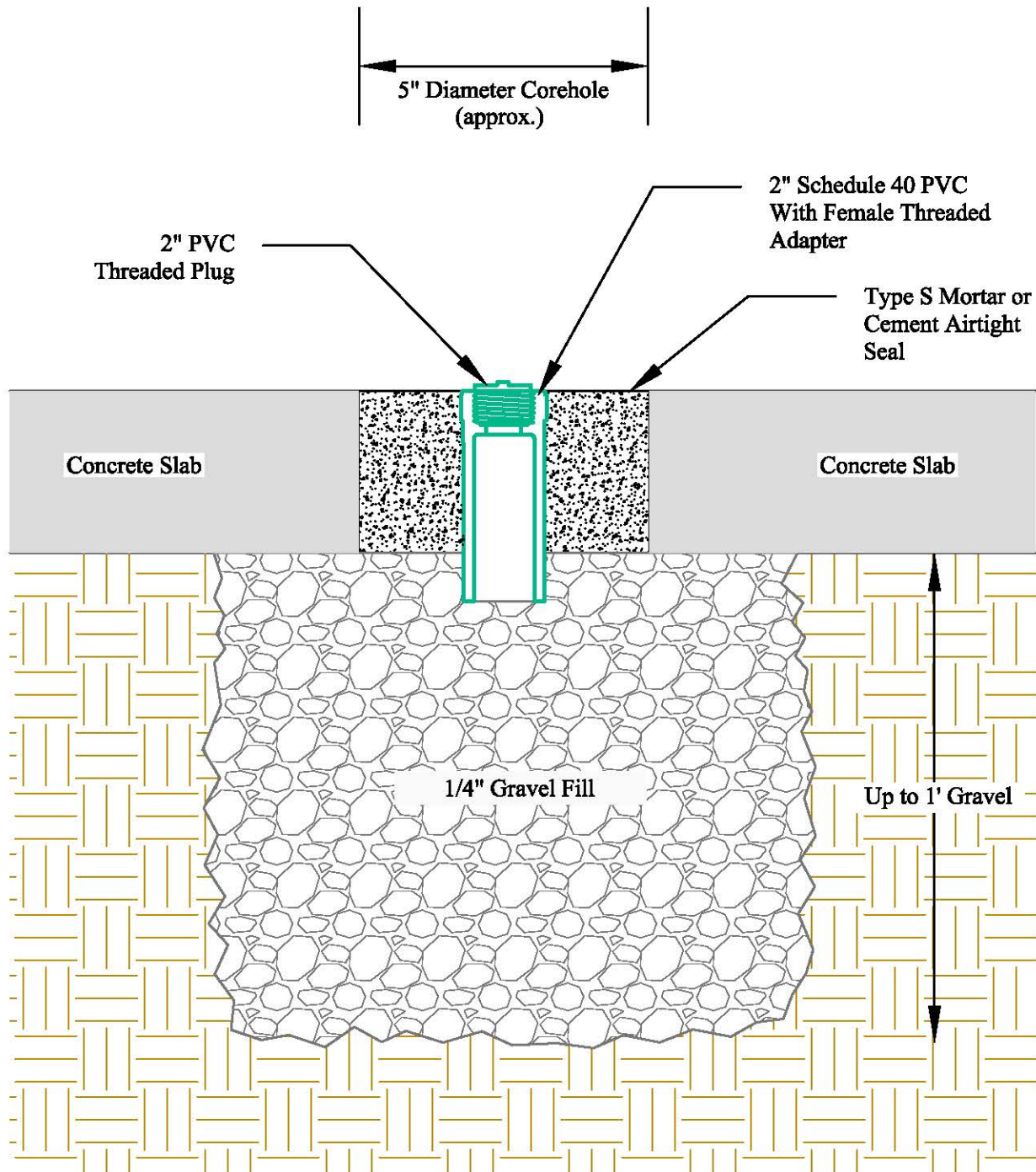


FIGURE A-2
SCHEMATIC CONSTRUCTION DIAGRAM
SUB-SLAB VAPOR EXTRACTION (SSVE) POINT

QUALITY ASSURANCE PROJECT PLAN

VAPOR EXTRACTION PILOT TEST

**UniFirst Property
Wells G&H Superfund Site
Woburn, Massachusetts**

July 2012

Submitted to:
**United States Environmental Protection Agency
Region 1**
5 Post Office Square, Suite 100
Boston, Massachusetts 02109-3912

Prepared for:
UniFirst Corporation
68 Jonspin Road
Wilmington, Massachusetts 01887

Prepared by:
The Johnson Company, Inc.
100 State Street, Suite 600
Montpelier, Vermont 05602



PARTNERS FOR SMART THINKING
AND CREATIVE STRATEGIES

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Figure 2	SVE Point and Observation Point Locations
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LIST OF APPENDICES (*provided on CD*)

Appendix 1	Analytical Method SOPs
Appendix 2	Project Sampling SOPs

Title: QAPP for Vapor Extraction Pilot Test
Site Name: UniFirst Property
Site Location: Woburn, Massachusetts

Revision Number: 0
Revision Date: 07/31/12
Page: 1 of 39

Form A
Title and Approval Page and Introduction

Quality Assurance Project Plan for Vapor Extraction Pilot Test
Document Title

Prepared by: The Johnson Company, Inc.
Prepared by

100 State Street, Suite 600, Montpelier, Vermont 05602 (802) 229-4600
Address and Telephone Number

07/31/12
Month/Day/Year

Project Manager: Bettina Longino
Signature

Project QA Officer: Deborah Gaynor
Signature
Bettina Longino
Printed Name/Date
Digitally signed by Deborah Gaynor
DN: cn=Deborah Gaynor, o=Phoenix
Chemistry Services, ou,
email=dgaynor@phoenixchemistryservic
es.com, c=US
Date: 2012.07.31 10:18:49 -04'00'

Deborah Gaynor
Printed Name/Date

USEPA Project Manager Approval: _____
Signature

Joseph F. LeMay
Printed Name/Date

USEPA Quality Assurance Approval: _____
Signature

Steve DiMattei
Printed Name/Date

Title: QAPP for Vapor Extraction Pilot Test
Site Name: UniFirst Property
Site Location: Woburn, Massachusetts

Revision Number: 0
Revision Date: 07/31/12
Page: 2 of 39

Form A Continued
Title and Approval Page and Introduction

This Quality Assurance Project Plan (QAPP) has been prepared on behalf of UniFirst Corporation (UniFirst) by The Johnson Company, Inc. (The Johnson Company) for submittal to the United States Environmental Protection Agency Region 1 (USEPA). This QAPP documents the sampling, analytical, and data review techniques that will be implemented during the vapor extraction pilot test (pilot test) that will be performed by The Johnson Company at the UniFirst Property located at 15 Olympia Avenue, Woburn, Massachusetts (the Property).

This QAPP describes procedures for making physical measurements and collecting soil, liquid, and vapor samples during the pilot test, and specifies quality assurance/quality control (QA/QC) procedures related to these tasks.

This QAPP has been prepared in general accordance with the March 2009 QAPP for the Norwood PCB Superfund Site Redevelopment provided by the USEPA as an example of an acceptable simplified QAPP format that includes all of the elements required by the USEPA QA/G-5 "Guidance for Quality Assurance Project Plans."

This QAPP is submitted to the USEPA Project Manager for review. Procedures described in this QAPP will be followed unless modifications and/or additions are documented in separate addenda or modification documents.

Distribution List

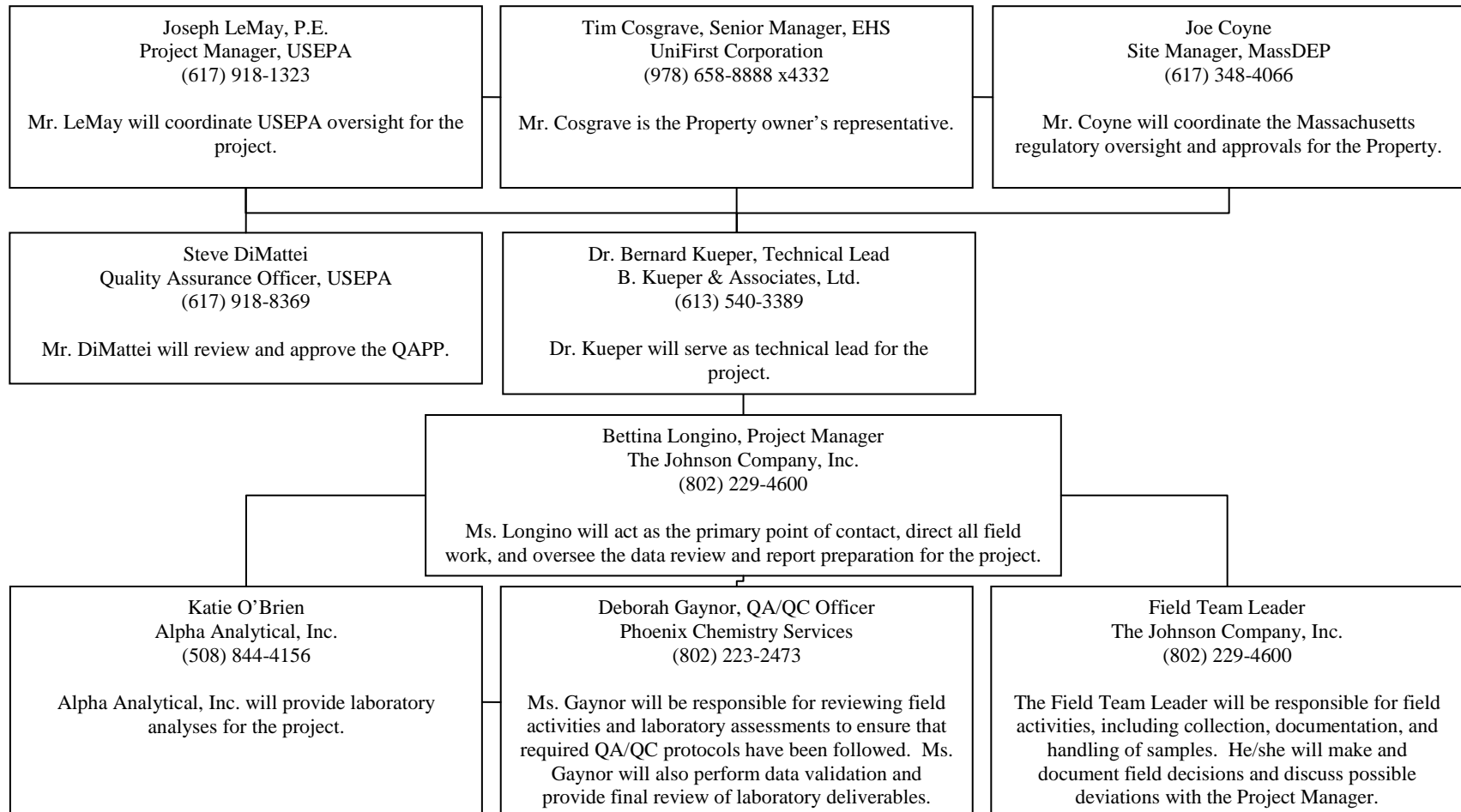
Names and telephone numbers of those receiving copies of this QAPP:

Joseph LeMay	USEPA	617-918-1323
Joseph Coyne	MassDEP	617-348-4066
Tim Cosgrave	UniFirst Corporation	978-658-8888
Bernard Kueper	B. Kueper & Associates, Ltd.	613-540-3389
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Form B
Project Organization and Responsibility



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Form C

Problem Definition/Background

The Property is located at 15 Olympia Avenue in Woburn, Massachusetts and consists of approximately 3 acres currently owned by UniFirst. The Property is located in an industrial area and is bordered by Olympia Avenue and residential properties to the south, industrial properties to the west, residences to the east, and the exit and entrance ramps to Interstate 95 to the north. There is one single-story, approximately 57,000-square foot (ft²) slab-on-grade building with concrete block walls located on the Property (Figure 1).

The Property was undeveloped prior to 1965. Building A was constructed in November 1965, Building B was constructed in 1966, and Building C was constructed in 1978 (Figure 1). In the late 1970s, the loading dock at the east end of the Property was upgraded and enclosed. The chronology of building construction and operating history of the Property have been documented in reports previously submitted to USEPA, including the letter from Harvard Project Services LLC (HPS) to Joseph LeMay dated January 8, 2010.

Since 1989, most of the building on the Property has been leased to Extra Space Storage, formerly known as Woburn Storage Depot. The leased space has been converted into storage units that are subleased individually to customers, and a small administration office located in the south central area of the building (Figure 1). UniFirst continues to use the northeast corner of the building for housing and operation of a groundwater treatment plant that is part of UniFirst's groundwater remedial action. An employee of Extra Space Storage works at the Property on a daily basis, primarily in the administration office. The building is staffed and accessible to Extra Space Storage customers approximately nine and a half hours a day from Monday through Saturday, and four hours on Sunday.

Extensive unconsolidated deposits investigations were undertaken at the Property in the 1980s and 1990s. The Property investigations identified two areas at the Property where chlorinated solvents were apparently released to ground surface: a waste-oil contamination area and an area to the south of the current loading dock. Focused source area characterizations showed that within the unconsolidated deposits these two release areas were limited in lateral extent, and that concentrations detected in soil samples implied the presence of residual dense nonaqueous phase liquid (DNAPL) in small discontinuous zones within each area. A substantial portion of the contaminated soils was removed during excavation of an influent line trench between 1992 and 1994. The characterization data also identified a zone of low to moderate tetrachloroethene (PCE) concentrations in soil vapor extending southwestward from the loading dock at the east end of the Property that was attributed to upward vapor migration from shallow groundwater.

Indoor air data measurements were collected inside the Property building in 1989. The risk assessment provided to USEPA for exposures within the building based on those indoor air data measurements concluded that there were no unacceptable risk levels within the building (*Summary of Unconsolidated-Deposits Investigations at the UniFirst Property, Woburn,*

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Massachusetts [Unconsolidated Deposits Report], Applied Groundwater Research, Ltd. and Environmental Project Control, Inc., 1994, pp 3-4 to 3-5). In 2009, USEPA requested that UniFirst re-evaluate potential vapor intrusion risks at the Property, based on calculations performed by the USEPA using historical soil and soil vapor samples collected under the existing building. Additional data were collected in 2010 and 2011 to monitor volatile organic compound (VOC) concentrations in groundwater samples from on-Property wells, sub-slab vapor beneath the on-Property building, and indoor air. Sub-slab soil vapor and indoor air samples were collected in the on-Property building in April 2010 and February 2011.

USEPA conducted a human health risk assessment based on the data collected in 2010 and 2011 and issued an *Addendum to the Third Five-Year Review* for the Wells G&H Superfund Site in April 2012 (April 2012 Addendum). In the April 2012 Addendum, USEPA concluded that the vapor intrusion pathway is not likely to pose unacceptable current or future indoor air risk at the UniFirst on-Property building under the current commercial use scenario. USEPA noted a potential unacceptable future indoor air risk associated with the vapor intrusion pathway at the on-Property building in the unlikely event it were to be used for residential purposes in the future. PCE and trichloroethene (TCE) were not identified at significant concentrations in any indoor air samples; however, USEPA noted that the presence of elevated concentrations of PCE and TCE in sub-slab soil gas beneath the building indicated a potential for a future vapor intrusion pathway to indoor air if building conditions were to change (e.g., future cracks in the foundation).

UniFirst is proposing to proceed with a multi-point vapor extraction pilot test at locations both under and adjacent to the on-Property building. The purpose of the pilot test is to collect data for purposes of designing a full-scale vapor extraction system. Pilot testing will be conducted at locations within the soil area with the highest concentrations of VOCs under and near the building, based on historical soil sampling data, historical operational features and information, and recent sub-slab vapor and shallow groundwater sampling data. The pilot test also will include vapor recovery points installed under the building slab where VOC impacts to soil vapor were observed at concentrations of potential concern. This QAPP details the procedures to be used during the pilot test.

Form D

Project Description/Timeline

The purpose of the vapor extraction pilot test is to collect data for purposes of designing a full-scale system. The objectives of the pilot test are to collect data from five soil vapor extraction (SVE) test points to:

- estimate radius of influence (ROI) and soil vapor flow velocities (i.e., the *ex situ* velocity of soil vapor extracted from the test point) at different applied vacuums;
- identify potential interference by subsurface structures that may influence extraction point ROI;
- assess possible anisotropy in extraction point ROI;
- evaluate the potential effect of vacuum-induced groundwater mounding;
- determine the expected range of VOC concentrations in extracted soil vapor; and
- determine the expected VOC constituent composition in extracted soil vapor.

During the pilot test, two shallow sub-slab vapor extraction (SSVE) points also will be installed and tested. The objectives of these installations are to evaluate the ROI for a sub-slab vacuum induced at each location and to determine the expected VOC constituent composition in extracted soil vapor from these points.

Soil samples will be collected during installation of each SVE test point for analysis of select volatile organic compounds (VOCs) and for hydrophobic dye testing to assess DNAPL presence. Soil samples also will be collected during installation of each pilot test observation point for hydrophobic dye testing. The objective of this soil sampling is to further characterize unconsolidated deposits in the area with the highest concentrations of residual VOC mass under and near the building.

Proposed locations for the SVE and SSVE test points are presented on Figure 1 and described below:

- SVE-1 is located in the waste-oil contamination area outside the Building B footprint and near the area where asphalt cover transitions to soil cover;
- SVE-2 is located within the modified footprint of Building B (i.e., the former loading dock area) in the area of highest anticipated VOC impact to soil and groundwater;
- SVE-3 is located near the former “gutter” in Building B in the area of highest observed VOC impact to sub-slab vapor in 2010 and 2011 samples;
- SVE-4 is located in Building B west of the original exterior perimeter footings and near monitoring well UC35, where elevated PCE concentrations were reported in shallow soil samples;
- SVE-5 is located outside of Building B in the area of former test pits TPI and TPM in an area of historically high VOC concentrations in soil;

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- SSVE-1 is located in Building B near former sub-slab vapor sampling location SV-07; and
- SSVE-2 is located in Building C near former sub-slab vapor sampling location SV-09.

SVE and SSVE locations are approximate and may be adjusted based on conditions encountered in the field.

Vacuum response to vapor extraction from the SVE points will be monitored using 31 newly-installed soil vapor monitoring (SVM) observation points (SVM-1 through SVM-31), up to five existing groundwater monitoring wells (UC32, UC33, UC34, UC35, and UC36), and six existing sub-slab vapor sampling locations (SV-06, SV-10, SV-11, SV-12, SV-13, and SV-15).

Additional monitoring points may be installed based on field observations (e.g., paired shallow and deep observation points may be installed if a subsurface asphalt layer is present in the vicinity of SVE-2). Observation points associated with each SVE test point are shown on Figure 2. SVM locations are approximate and may be adjusted based on conditions encountered in the field.

Vacuum response to vapor extraction from the SSVE points will be monitored using four newly-installed, small-diameter floor slab penetrations and seven existing sub-slab vapor sampling locations (SV-04, SV-05, SV-06, SV-07, SV-10, and SV-13 near SSVE-1; SV-09 near SSVE-2). If vacuum response is not observed in these observation points, additional small-diameter penetrations through the floor slab may be made to provide additional observation points. Observation points associated with each SSVE test point are shown on Figure 3. Observation point locations are approximate and may be adjusted based on conditions encountered in the field.

Vacuum step tests will be performed at each SVE and SSVE test point, and a constant rate vacuum test will be performed at each SVE point. During each step in the step test, the applied vacuum will be held approximately constant for up to 2 hours before increasing the vacuum to the next successive step. At least three different vacuum steps will be attempted at each test point. Data collected during the step tests will be used to select a constant rate test vacuum for the constant rate test at each SVE point. The anticipated duration for each constant rate test is approximately 48 hours, but the duration may be shortened or extended based on responses observed during testing. At the end of a particular constant rate test, an approximately 8- to 12-hour (overnight) recovery period will be allowed prior to commencing the next constant rate test. Details of the measurement and sampling procedures to be followed during the step and constant rate vacuum tests are provided in Form E.

Samples of extracted soil vapor collected for laboratory analysis during the pilot test will be analyzed for Modified EPA Method TO-15 list VOCs (see Form K). Samples of soil vapor condensate collected for laboratory analysis during the pilot test will be analyzed for PCE, TCE, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), and trans-1,2-dichloroethene (trans-1,2-DCE) (see Form K). Soil samples for

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laboratory analysis collected from each SVE point boring will be analyzed for chloroform, PCE, TCE, 1,1,1-TCA, and trans-1,2-DCE (see Form K). Extracted soil vapor samples will be analyzed at Alpha Analytical, Inc. (Alpha) at its Mansfield, Massachusetts laboratory; soil and soil vapor condensate samples will be analyzed at Alpha's Westborough, Massachusetts laboratory. Alpha is a NELAC (MA015/MA935) certified laboratory.

All data collected during the pilot test will be presented in the pilot test report, either in tabular format or in appended completed field forms and laboratory reports. The pilot test report will include a summary of the work conducted and the data validation performed. Electronic tables of validated laboratory data also will be included with the pilot test report.

Project Timeline

The proposed project timeline is summarized below.

Activity	Activity Start	Activity End
USEPA Pilot Test Work Plan and QAPP approval (4 weeks)	7/31/12	8/31/12
Field Preparation (4 weeks)	9/4/12	9/28/12
Pre-mark drilling locations, install extraction and monitoring points, conduct soil sampling (2.5 weeks)	10/1/12	10/17/12
Setup and vacuum step testing (1.5 weeks)	10/18/12	10/26/12
Constant rate testing and demobilization (2.5 weeks)	10/29/12	11/14/12
Receipt and validation of laboratory analytical data (6 weeks)	11/19/12	12/28/12
Pilot Test Report preparation (6 weeks)	12/31/13	2/8/13
Pilot Test Report submitted to USEPA	2/12/13	2/12/13

Form E

Sampling Design

Sampling of soil, extracted soil vapor, and soil vapor condensate will be performed according to the Standard Operating Procedures (SOPs) listed on Form G. Samples will be analyzed at Alpha for the analytes specified on Form K. Procedures for sample collection and field measurements are described below, with reference to SOPs where applicable.

Vacuum Step Tests – SVE and SSVE Test Points

Vacuum step tests will be performed at each SVE and SSVE test point. During each step in the vacuum step test, the applied vacuum will be held approximately constant for up to 2 hours before increasing the vacuum to the next successive step. At least three different vacuum steps will be attempted for each test point. During each step at each test point, field personnel will maintain a log sheet summarizing the following:

- location, date, and step test start and stop times;
- identity of field personnel;
- applied vacuum at the test point;
- velocity of extracted vapor;
- temperature of extracted vapor;
- time of extracted vapor sample collection into Tedlar® bag;
- photoionization detector (PID) reading of extracted vapor sample in Tedlar® bag and of ambient air;
- response vacuum at targeted observation points;
- dilution air vacuum;
- velocity of dilution air;
- temperature of dilution air;
- time of treatment system vapor effluent sample collection into Tedlar® bag;
- PID reading of vapor effluent sample from Tedlar® bag and ambient air; and
- condensate production in the vapor-liquid separator.

At least three measurements will be collected during each step of the test.

Each SVE point will be instrumented with pressure transducers to monitor potential vacuum-induced groundwater mounding during step testing; SSVE points will not be instrumented with pressure transducers to monitor potential vacuum-induced groundwater mounding. After step testing is complete at an SVE test point, the pressure transducers will be removed from the test point and the data will be downloaded to a field laptop.

Constant Rate Vacuum Tests – SVE Points

Constant rate vacuum tests will be performed at each SVE test point; constant rate vacuum tests will not be performed at SSVE test points. The vacuum for the constant rate test at each SVE test point will be determined based on the step test results for that SVE test point. The highest

step test vacuum at the SVE test point that did not result in groundwater upwelling and decreased air flow through the SVE test point well screen will be used for the constant rate test. The duration of each constant rate test is anticipated to be approximately 48 hours, but may be shortened or extended based on responses observed during the test. During each constant rate test, field personnel will maintain a log sheet summarizing the following:

- location, date, and start and stop times for individual test measurements;
- identity of field personnel;
- applied vacuum at the test point;
- velocity of extracted vapor;
- temperature of extracted vapor;
- time of extracted vapor sample collection into Tedlar® bag;
- PID reading of extracted vapor sample in Tedlar® bag and of ambient air;
- dilution air vacuum;
- velocity of dilution air;
- temperature of dilution air;
- time of treatment system vapor effluent sample collection into Tedlar® bag;
- PID reading of vapor effluent sample from Tedlar® bag and ambient air; and
- condensate production in the vapor-liquid separator.

Measurements will be recorded: prior to starting the blower (vacuum measurement only); after 1 hour, 2 hours, 4 hours, and 8 hours of operation; daily thereafter; and immediately prior to shutdown of the constant rate test.

At the end of each constant rate test, the vacuum will be turned off for approximately 8 to 12 hours to allow for recovery prior to starting the next constant rate test.

During each constant rate test, field personnel will maintain a log sheet of response vacuum at targeted observation points. Measurements will be recorded: prior to starting the blower; hourly for the first 4 hours of the constant rate test; after 8 hours of operation; at least twice daily thereafter; and immediately prior to shutdown of the constant rate test.

Each SVE test point will be instrumented with pressure transducers to monitor potential vacuum-induced groundwater mounding during constant rate testing. After the constant rate test recovery period is complete at an SVE test point, the pressure transducers will be removed from the test point and the data will be downloaded to a field laptop.

Vacuum Measurements

During the vacuum step tests and the constant rate vacuum tests, vacuum will be measured at the extraction test points, targeted observation points, and in the dilution air line. Measurements will be made using a factory-calibrated digital manometer (Dwyer Model 476A or similar) connected to the barbed fitting on the measurement port using a piece of silicone tubing.

Extracted Vapor Velocity Measurements

During the vacuum step tests and the constant rate vacuum tests, the velocity of the extracted vapor stream will be measured at a port located in the extracted vapor stream piping between the extraction test point and the blower. The velocity measurement will be made at the approximate center of the pipe's cross-sectional area with the instrument oriented parallel to the direction of the pipe. Where possible, the measurement port will be located at least 7.5 pipe diameters downstream from and at least 3 pipe diameters upstream from any pipe fittings or flow obstructions. Velocity measurements will be made using a factory-calibrated Dwyer Series 471 Thermo-Anemometer or similar.

Vapor Sampling (Field Screening)

Field screening using a PID will be performed on vapor samples collected during the step tests and constant rate tests. A disposable Tedlar® bag will be placed in a vacuum box and connected to a sampling port with a length of new Teflon tubing. The procedure for collecting vapor samples in Tedlar® bags using a vacuum box is described in SOP-JCO-045 (attached in Appendix 2). The PID will be calibrated daily (SOP-JCO-044).

Vapor Sampling (Laboratory Analysis)

Three vapor samples for laboratory analysis of VOCs will be collected during the constant rate test at each SVE test point. Vapor samples for laboratory analysis will be collected within 2 two hours of startup, at the approximate midpoint of the test, and immediately prior to shutdown of the constant rate test. Vapor samples for laboratory analysis will be collected in pre-cleaned, batch certified, 6-liter passivated canisters supplied by Alpha.

Before collecting a sample, a calibrated (NIST-traceable) digital handheld pressure gauge will be used to verify canister vacuums; readings taken from the laboratory-supplied pressure gauge will also be recorded. After verifying the vacuum, a piece of new silicone tubing will be used to connect the barbed fitting on the sampling port to the barbed fitting on the Summa® canister. Samples will be collected as grab samples; time-compositing flow controllers will not be used. Samples will be collected by opening the valves on the sampling port and Summa® canister and allowing the canister to fill. Because the pressure at the sampling port will be less than atmospheric pressure, a negative pressure will be maintained in the canister after sample collection. The remaining vacuum in the canister will be measured with the digital pressure gauge and laboratory-supplied pressure gauge and recorded.

The following information will be recorded for each sample:

- sample identification;
- date and time of sample collection;
- identity of sampler;
- canister vacuum before and after sample collection using both gauges;
- canister identification;
- vacuum at sample collection point before taking the sample; and
- chain-of-custody form number.

Sampling canisters will be packaged in laboratory-supplied boxes and delivered to Alpha under chain-of-custody protocol. The laboratory-supplied pressure gauge will be returned with the sampling canisters and used by Alpha to check the canister vacuum upon receipt at the laboratory. Samples will be analyzed by Alpha using a modified EPA TO-15 method. The modifications to the TO-15 method used by the laboratory are described in the Alpha SOP 2186, attached in Appendix 1. Sample concentrations may range from less than 1 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) to greater than $10^5 \mu\text{g}/\text{m}^3$ for some analytes. Low level concentrations of some analytes may be present in samples that require dilution. If a sample dilution is required, an additional, more concentrated analysis will be performed.

Soil Vapor Condensate Sampling (Laboratory Analysis)

The blower used for the pilot test will be equipped with a liquid knockout tank in which condensate may accumulate during vapor extraction. If the volume of condensate that accumulates in the liquid knockout tank during the constant rate test at an SVE test point is sufficient to fill three 40-milliliter (mL) volatile organic analysis (VOA) vials, a sample of the condensate will be collected for laboratory analysis. The sample will be collected either by directly filling the VOA vials or by pumping from the knockout tank with a peristaltic pump, depending on the configuration of the knockout tank. Samples will be placed in a cooler on ice and delivered to Alpha under chain-of-custody protocol. A laboratory-supplied trip blank will accompany the VOA vials containers from and to the laboratory. Samples and the trip blank will be analyzed by Alpha for PCE, TCE, 1,1,1-TCA, 1,1-DCE, cis-1,2-DCE, and trans-1,2-DCE using EPA Method 8260B (Alpha SOP 2108).

Soil Sampling (Laboratory Analysis)

Soil samples for laboratory analysis will be collected from the core obtained during installation of SVE test points SVE-1 through SVE-5. At each location, one sample of fill/reworked materials and one sample of till, if present, will be collected for laboratory analysis. Soil samples will be collected from continuous soil cores obtained using a split spoon sampler. Samples for laboratory analysis will be collected from a stained interval (if visible impact is observed) or from the interval with the highest PID reading (if visible impact is not observed). If PID readings along the soil core do not exceed background, the soil samples for laboratory analysis will be collected from the bottom of the lithologic horizon or boring. Soil samples will be collected using a Terra Core® sampler or other suitable coring device. Each soil sample will consist of four, 40-mL VOA vials. Per SW-846 Method 5035A, two of the 40-mL vials will contain deionized water, one will contain methanol, and one vial will be empty. Deionized water and methanol will be added to the vials by Alpha before delivery to the Property. Approximately 15 grams of soil will be added to the vial with methanol; approximately 5 grams will be added to the other vials. Immediately after collection, soil samples will be placed in a cooler on ice and delivered to Alpha under chain-of-custody protocol within 48 hours of collection, and the soils in water vials will be frozen upon receipt. A laboratory-supplied trip blank will accompany the VOA vials from and to the laboratory. Samples and the trip blank will be analyzed by Alpha for chloroform, PCE, TCE, trans-1,2-DCE, and 1,1,1-TCA using EPA Method 8260B.

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Soil Sampling (Hydrophobic Dye Testing)

Soil samples for field hydrophobic dye testing will be collected from the soil core obtained during installation of test points SVE-1 through SVE-5 and observation points SVM-1 through SVM-31. Soil samples will be collected from continuous soil cores obtained using a split spoon sampler. Soil samples for hydrophobic dye testing will be collected after soil samples for laboratory analysis have been collected (described above). A soil sample for hydrophobic dye testing will be collected from each interval where NAPL, sheen, or staining is observed, or where an abrupt increase in PID reading is noted. Approximately 15 mL of soil will be collected from the target sample interval using a Terra Core® sampler and placed in a clear 40-mL glass VOA vial. Deionized water will be added to the VOA vial until approximately 10 to 15 mL of headspace remains in the VOA vial. At least 0.5 grams of Oil-Red-O dye powder will be added to the VOA vial, and the cap will be secured. The VOA vial will be shaken vigorously for approximately 20 seconds and then examined for red staining produced by dissolution of the Oil-Red-O dye powder in NAPL. Dye testing results will be indicated on the boring log.

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Form F
Sampling and Analytical Methods Requirements

Sample Matrix	Parameter	Number of Samples (including field QC samples)	Analytical Method ⁺ (SOP)*	Sampling SOP*	Sample Containers (number per sample, size, and type)	Sample Preservation (temperature, light, chemical)	Maximum Holding Time
Extracted Soil Vapor	VOCs (PID Screening)	Regular intervals during step tests and constant rate tests	None	4c, 5c	1 @ 1 liter Tedlar® bag	None	Screen sample immediately after collection
Extracted Soil Vapor	VOCs-Laboratory	15 samples (3 from each SVE test point)	Modified EPA TO-15 (2b)	None	1 @ 6 liter Stainless steel, passivated canister	None	30 days
Condensate from Extracted Soil Vapor	VOCs-Laboratory	Up to 5 aqueous samples (1 from each SVE test point) + trip blanks	EPA Method 8260b (3b)	None	3 @ 40 mL volatile organic analysis (VOA) vials	HCl, 4° ± 2°C	14 days
Soil	VOCs-Laboratory	10 samples (2 from each SVE test point) + 1 field duplicate + trip blanks	EPA Method 8260b (3b)	6c	4 @ 40 mL volatile organic analysis (VOA) vials	Methanol (1 vial), 4° ± 2°C Deionized water (2 vials). -7°C to -20°C	Analyze within 14 days

⁺ The current analytical method in use by the laboratory at the time of analysis will be applied.

* Form G contains method and SOP reference tables.

Abbreviations:

VOC = volatile organic compound

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Form G
Method and SOP Reference Table

Analytical Method Reference¹: Includes document title, method name/number, revision number, and date	
No.	Analytical Method Name
1a	EPA Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS), 01/1999. EPA/625/R-96/010b.
2a	EPA Method 8260B, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS), 12/1996.

¹ Analytical method is referenced in the laboratory's SOP.

Project Analytical Standard Operating Procedures (SOPs)²: Includes document title, date, revision number, and originator's name	
No.	Analytical SOP Name
1b	Alpha SOP 2190: Cleaning and Preparation Procedures for Equipment Used to Collect Air Samples for Analysis of Volatile Organic Compounds (VOCs), 3/2012, Issue No.4 Rev 1, Alpha Analytical, Inc.
2b	Alpha SOP 2186: Determination of Volatile Organic Compounds in Ambient Air Using Specially-Prepared Canisters and Analyzed by GC/MS, 3/2012, Issue No. 7 Rev 2, Alpha Analytical, Inc.
3b	Alpha SOP 2108: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS), 3/2012, Issue No. 13, Alpha Analytical, Inc.

² SOPs included in Appendix 1.

Project Sampling SOPs³: Includes document title, date, revision number, and originator's name	
No.	Sampling SOP Name
1c	SOP-JCO-007 Standard Operating Procedure for Chain-of-Custody Records, 3/96, Rev. 6, The Johnson Company, Inc.
2c	SOP-JCO-018 Standard Operating Procedure for Deviation from Protocols or Standard Operating Procedures and for Notation, Correction, and Documentation of Unforeseen Circumstances, 7/94, Rev. 1, The Johnson Company, Inc.
3c	SOP-JCO-027 Standard Operating Procedure for Decontamination of Field Equipment, 3/96, Rev. 4, The Johnson Company, Inc.
4c ⁴	SOP-JCO-044 Standard Operating Procedure for Calibration and Operation of the MiniRAE 3000 Portable Handheld VOC Photo-Ionization Detector, 02/10, Rev 0 (draft), The Johnson Company, Inc.
5c ⁴	SOP-JCO-045 Standard Operating Procedure for Tedlar® Bag Sampling 06/12, Rev 0 (draft), The Johnson Company, Inc.
6c ⁴	SOP-JCO-021 Standard Operating Procedures for Soil Sampling for Volatile Organic Compounds, 06/07, Rev 0, The Johnson Company, Inc.

³ Project sampling SOPs include sample collection, sample preservation, equipment decontamination, preventive maintenance, etc.

⁴ SOPs included in Appendix 2.

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Form H
Field Equipment Calibration and Corrective Action

Instrument	Calibration Activity	Frequency	Acceptance Criteria	Corrective Action	SOP Reference*
MiniRAE 3000 PID with 11.7 eV lamp	Calibration for VOCs with 100 ppm isobutylene standard	At least once daily, more often if response is slow. Check calibration midday and at end of day.	±2%	Clean lamp and unit; re-zero and recalibrate with 100 ppm isobutylene	4c
Dwyer Digital Manometer Model 476A or similar	Must be calibrated at factory.	Once yearly.	Factory- determined	Factory- determined	Not applicable
Dwyer Digital Thermo Anemometer Model 471B or similar	Must be calibrated at factory.	Once yearly.	Factory- determined	Factory- determined	Not applicable
Dwyer Digital Pressure Gauge DPGA-00	Must be calibrated at factory.	Once yearly.	Factory- determined	Factory- determined	Not applicable

*Form G contains the SOP reference table.

Abbreviation:

ppm = part per million

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Form H (continued)
Inspection/Acceptance Requirements for Supplies and Consumables

Supplies	Inspection Frequency	Type of Inspection	Responsible Party	Corrective Action
Calibration gas for PID	During mobilization preparation	Verify positive pressure in canister	Sampler	Replace or fill canister
Chains of custody for samples	During mobilization preparation	Verify that appropriate type and number of forms will accompany samples	Sampler	Obtain additional copies before sampling
Vacuum pump	During mobilization preparation	Verify equipment is in working condition	Sampler	Replace or repair defective equipment
Anemometer	During mobilization preparation	Verify equipment is in working condition; check batteries	Sampler	Replace or repair defective equipment
Tedlar® bags	During mobilization preparation	Verify bags are not damaged	Sampler	Replace damaged bags.
VOA vials	Upon receipt	Verify containers are not damaged and contain preservatives.	Sampler	Request new containers.
Passivated Canisters (Summa® or fused silica lined)	Upon receipt	Verify canisters are not damaged and appropriate cleaning certifications are included, check for a vacuum using a digital vacuum gauge in outdoor air	Sampler	Do not use rejected canisters. Obtain additional canisters from laboratory.
Vacuum gauge	During mobilization preparation	Verify that the instrument was calibrated within the previous 1 year	Sampler	Submit for calibration if calibration date exceeds 1 year
Digital manometer	During mobilization preparation	Verify that the instrument was calibrated within the previous 1 year	Sampler	Submit for calibration if calibration date exceeds 1 year
Pressure transducers	During mobilization preparation	Verify equipment is in working condition	Sampler	Replace or repair defective equipment
Electronic data storage media	During use and upon saving data, before any paper data is destroyed	Verify that all files are stored on the local area network in the correct location	Project Manager	Move to correct location or re-save data in correct location

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Form I
Laboratory Equipment Calibration and Corrective Action

Instrument	Activity	Frequency	Acceptance Criteria	Corrective Action	SOP Ref*
GC/MS (TO-15, 8260B)	Tuning criteria	Every 12 (8260B) or 24 hours on all days of analysis, including initial calibration	Bromofluorobenzene (BFB) spectrum must meet criteria in Table 5 of the TO-15 SOP, or Table 3 of the 8260B SOP, regarding Key Ion Abundance Criteria.	Re-evaluate BFB spectrum before analyzing samples, reanalyze BFB. Retune instrument if new spectrum fails.	2b and 3b
GC/MS (TO-15)	Initial 5-point calibration	Before sample analysis	Relative standard deviation (RSD) of the response factors $\leq 30\%$. If a target analyte cannot meet the %RSD criteria for relative response factor calibration, then linear regression may be used with at least 5 calibration points and a correlation coefficient of 0.995 or greater. If a compound is calibrated using linear regression then after the initial calibration verification (ICV) and before sample analysis, a low point standard must be analyzed to confirm there is no bias from the linear regression calibration used. Recovery of the low point standard must be 60-140% using the linear regression curve.	Recalibrate and repeat Initial Calibration. If linear regression fails, prepare a new set of calibration standards and recalibrate.	2b
GC/MS (8260B)	Initial 7-point or 8-point calibration	Before sample analysis	Must obtain minimum relative response factors specified in SOP for the five system performance check compounds (SPCCs). $RSD \leq 30\%$ must be achieved for all target analytes (Forms E and K).	Evaluate necessity of corrective actions specified in SOP, recalibrate instrument.	3b
GC/MS (8260B, TO-15)	ICV sample	After every initial calibration	Average response factor must be within 30% of initial calibration. If any exceedances occur, repeat ICV.	If second ICV is not within criteria, investigate possible causes of failure or recalibrate instrument.	2b and 3b
GC/MS (TO-15)	Continuing calibration verification (CCV/LCS)	Before sample analysis.	Percent difference of the continuing calibration response factor from the initial calibration response factor must be $\leq 30\%$. Four compounds (1,2,4-trichlorobenzene, 1,4-dioxane, acetone, and hexachlorobutadiene) may exhibit up to 50% difference. If exceedances occur, repeat the CCV.	If the CCV/LCS analysis fails a second time, recalibrate instrument.	2b

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Form I (continued)
Laboratory Equipment Calibration and Corrective Action

Instrument	Activity	Frequency	Acceptance Criteria	Corrective Action	SOP Ref*
GC/MS (8260B)	CCV	At the beginning of each 12-hour shift	Relative response factors for the five SPCCs must meet minimum response factor criteria in SOP. Percent difference or percent drift for each CCC must be $\leq 20\%$. Percent drift should be $< 25\%$ for all target analytes in Forms E and K.	Perform maintenance or recalibrate instrument.	3b

*Form G contains the method and SOP reference tables.

Abbreviations:

GC/MS = gas chromatograph/mass spectrometer

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Form J
Sample Handling and Custody Requirements

Laboratory Samples

Sample containers will be labeled with the sample ID, site name, date, time, sampler's initials, and required analysis.

As described in Project Sampling SOP 1c, the chain-of-custody record tracks possession and handling of individual samples from the time of field collection through laboratory analysis. Samples designated for laboratory analysis will be accompanied by a completed chain-of-custody form. An example chain-of-custody form is provided on the following page.

Soil and water samples will be carefully packed in coolers with bubble wrap or other suitable packaging material to avoid damage. Coolers will be sealed with chain-of-custody tape marked with the date of packaging and the sampler's signature. An example chain-of-custody tape is shown on page 22 of this QAPP. Air sampling canisters will be carefully packed in laboratory-supplied packaging.

Waste sample material will be disposed of by the analytical laboratory in accordance with applicable regulations.

Screening Samples

All screening-level analyses will be completed on-Property by The Johnson Company.

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AIR ANALYSIS PAGE _____ OF _____												Date Rec'd In Lab:		ALPHA Job #:											
CHAIN OF CUSTODY												Report Information - Data Deliverables		Billing Information											
320 Forbes Blvd, Mansfield, MA 02048 TEL: 508-822-9300 FAX: 508-822-3288						Project Information Project Name: _____ Project Location: _____ Project #: _____ Project Manager: _____ ALPHA Quote #: _____						<input type="checkbox"/> FAX <input type="checkbox"/> ADEX Criteria Checker: _____ <i>(Default based on Regulatory Criteria Indicated)</i> Other Formats: _____ <input type="checkbox"/> EMAIL (standard pdf report) <input type="checkbox"/> Additional Deliverables: _____ Report to: (if different than Project Manager) _____		<input type="checkbox"/> Same as Client Info PO #: _____											
Client Information Client: _____ Address: _____ Phone: _____ Fax: _____ Email: _____ <input type="checkbox"/> These samples have been previously analyzed by Alpha						Turn-Around Time <input type="checkbox"/> Standard <input type="checkbox"/> RUSH <i>(only confirmed if pre-approved)</i> Date Due: _____ Time: _____						Regulatory Requirements/Report Limits <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>State/Fed</th> <th>Program</th> <th>Criteria</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>		State/Fed	Program	Criteria									
State/Fed	Program	Criteria																							
Other Project Specific Requirements/Comments: _____																									
All Columns Below Must Be Filled Out																									
ALPHA Lab ID (Lab Use Only)	Sample ID	Collection					Sample Matrix*	Sampler's Initials	Can Size	I D Can	I D - Flow Controller	ANALYSIS						Sample Comments (i.e. PID)							
		Date	Start Time	End Time	Initial Vacuum	Final Vacuum						TO-14A by TO-15	TO-15	TO-15 SIM	APH	FIXED GASES	TO-13A		TO-4 / TO-10						
*SAMPLE MATRIX CODES		AA = Ambient Air (Indoor/Outdoor) SV = Soil Vapor/Landfill Gas/SVE Other = Please Specify						Container Type										Please print clearly, legibly and completely. Samples can not be logged in and turnaround time clock will not start until any ambiguities are resolved. All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.							
		Relinquished By:		Date/Time				Received By:		Date/Time:															
Form No: 101-02 (10-Jun-09)																									

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100 State Street
Montpelier, VT 05602
(802) 229-4600

THE JOHNSON COMPANY, INC.

Signature: _____

Date: _____

C.O.C. No. _____

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Form K
Analytical Sensitivity and Project Criteria

Analyte	Analytical Method ¹	Laboratory Target Reporting Limit (units)	Lab Replicate Precision Difference (%)	Accuracy Limit (%)
<i>Laboratory Air Analysis (Extracted Soil Vapor)- SOPs 1a and 2b</i>				
1,1,1-Trichloroethane	TO-15	1.09 µg/m ³	25	70-130
1,1,2,2-Tetrachloroethane	TO-15	1.37 µg/m ³	25	70-130
1,1,2-Trichloroethane	TO-15	1.09 µg/m ³	25	70-130
1,1-Dichloroethane	TO-15	0.81 µg/m ³	25	70-130
1,1-Dichloroethene	TO-15	0.79 µg/m ³	25	70-130
1,2,4-Trichlorobenzene	TO-15	1.48 µg/m ³	25	50-150
1,2,4-Trimethylbenzene	TO-15	0.98 µg/m ³	25	70-130
1,2-Dibromoethane	TO-15	1.54 µg/m ³	25	70-130
1,2-Dichlorobenzene	TO-15	1.2 µg/m ³	25	70-130
1,2-Dichloroethane	TO-15	0.81 µg/m ³	25	70-130
1,2-Dichloropropane	TO-15	0.92 µg/m ³	25	70-130
1,3,5-Trimethylbenzene	TO-15	0.98 µg/m ³	25	70-130
1,3-Butadiene	TO-15	0.44 µg/m ³	25	70-130
1,3-Dichlorobenzene	TO-15	1.2 µg/m ³	25	70-130
1,4-Dichlorobenzene	TO-15	1.2 µg/m ³	25	70-130
1,4-Dioxane	TO-15	0.72 µg/m ³	25	50-150
2,2,4-Trimethylpentane	TO-15	0.93 µg/m ³	25	70-130
2-Butanone (MEK)	TO-15	0.59 µg/m ³	25	70-130
2-Hexanone	TO-15	0.82 µg/m ³	25	70-130
3-Chloropropene	TO-15	0.63 µg/m ³	25	70-130
4-Ethyltoluene	TO-15	0.98 µg/m ³	25	70-130
Acetone	TO-15	2.36 µg/m ³	25	50-150
Benzene	TO-15	0.64 µg/m ³	25	70-130
Benzyl Chloride	TO-15	1.03 µg/m ³	25	70-130

¹ Form G contains the method and SOP reference tables.

Abbreviation:

µg/m³ = microgram per cubic meter

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Form K (continued)
Analytical Sensitivity and Project Criteria

Analyte	Analytical Method ¹	Laboratory Target Reporting Limit (units)	Lab Replicate Precision Difference (%)	Accuracy Limit (%)
<i>Laboratory Air Analysis (Extracted Soil Vapor)- SOPs 1a and 2b</i>				
Bromodichloromethane	TO-15	1.34 µg/m ³	25	70-130
Bromoform	TO-15	2.07 µg/m ³	25	70-130
Bromomethane	TO-15	0.78 µg/m ³	25	70-130
Carbon Disulfide	TO-15	0.62 µg/m ³	25	70-130
Carbon Tetrachloride	TO-15	1.26 µg/m ³	25	70-130
Chlorobenzene	TO-15	0.92 µg/m ³	25	70-130
Chloroethane	TO-15	0.53 µg/m ³	25	70-130
Chloroform	TO-15	0.98 µg/m ³	25	70-130
Chloromethane	TO-15	0.41 µg/m ³	25	70-130
Cis-1,2-Dichloroethene	TO-15	0.79 µg/m ³	25	70-130
Cis-1,3-Dichloropropene	TO-15	0.91 µg/m ³	25	70-130
Cyclohexane	TO-15	0.69 µg/m ³	25	70-130
Dibromochloromethane	TO-15	1.7 µg/m ³	25	70-130
Dichlorodifluoromethane	TO-15	0.99 µg/m ³	25	70-130
Ethanol	TO-15	4.71 µg/m ³	25	70-130
Ethyl Acetate	TO-15	1.8 µg/m ³	25	70-130
Ethylbenzene	TO-15	0.87 µg/m ³	25	70-130
Freon-113	TO-15	1.53 µg/m ³	25	70-130
Freon-114	TO-15	1.4 µg/m ³	25	70-130
Hexachlorobutadiene	TO-15	2.13 µg/m ³	25	50-150
Hexane	TO-15	0.7 µg/m ³	25	70-130
Isopropyl Alcohol	TO-15	1.23 µg/m ³	25	70-130
Methylene Chloride	TO-15	3.46 µg/m ³	25	70-130

¹ Form G contains the method and SOP reference tables.

Abbreviation:

µg/m³ = microgram per cubic meter

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Form K (continued)
Analytical Sensitivity and Project Criteria

Analyte	Analytical Method ¹	Laboratory Target Reporting Limit (units)	Lab Replicate Precision Difference (%)	Accuracy Limit (%)
<i>Laboratory Air Analysis (Extracted Soil Vapor)- SOPs 1a and 2b</i>				
Methyl isobutyl ketone	TO-15	0.82 µg/m ³	25	70-130
Methyl tert butyl ether	TO-15	0.72 µg/m ³	25	70-130
m&p-Xylene	TO-15	1.74 µg/m ³	25	70-130
N-Heptane	TO-15	0.82 µg/m ³	25	70-130
O-Xylene	TO-15	0.87 µg/m ³	25	70-130
Propylene	TO-15	0.34 µg/m ³	25	70-130
Styrene	TO-15	0.85 µg/m ³	25	70-130
Tetrachloroethene	TO-15	1.36 µg/m ³	25	70-130
Tetrahydrofuran	TO-15	0.59 µg/m ³	25	70-130
Toluene	TO-15	0.75 µg/m ³	25	70-130
Trans-1,2-Dichloroethene	TO-15	0.79 µg/m ³	25	70-130
Trans-1,3-Dichloropropene	TO-15	0.91 µg/m ³	25	70-130
Trichloroethene	TO-15	1.07 µg/m ³	25	70-130
Trichlorofluoromethane	TO-15	1.12 µg/m ³	25	70-130
Vinyl Acetate	TO-15	0.70 µg/m ³	25	70-130
Vinyl Bromide	TO-15	0.87 µg/m ³	25	70-130
Vinyl Chloride	TO-15	0.51 µg/m ³	25	70-130

¹ Form G contains the method and SOP reference tables.

Abbreviation:

µg/m³ = microgram per cubic meter

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Form K (continued)
Analytical Sensitivity and Project Criteria

Analyte	Analytical Method ¹	Laboratory Target Reporting Limit (units)	Lab Replicate Precision Difference (%)	Accuracy Limit (%)
<i>Laboratory Water Analysis (Extracted Soil Vapor Condensate) – SOPs 2a and 3b</i>				
1,1,1-Trichloroethane	8260B	0.5 µg/L	25	70-130
1,1-Dichloroethene	8260B	0.5 µg/L	25	70-130
Cis-1,2-Dichloroethene	8260B	0.5 µg/L	25	70-130
Trans-1,2-Dichloroethene	8260B	0.75 µg/L	25	70-130
Tetrachloroethene	8260B	0.5 µg/L	25	70-130
Trichloroethene	8260B	0.5 µg/L	25	70-130
<i>Laboratory Soil Analysis – SOPs 2a and 3b</i>				
1,1,1-Trichloroethane	8260B	1.0 µg/kg	25	70-130
Chloroform	8260B	1.5 µg/kg	25	70-130
Tetrachloroethene	8260B	1.0 µg/kg	25	70-130
Trans-1,2-Dichloroethene	8260B	1.5 µg/kg	25	70-130
Trichloroethene	8260B	1.0 µg/kg	25	70-130

¹ Form G contains the method and SOP reference tables.

Abbreviations:

µg/L = microgram per liter

µg/kg = microgram per kilogram

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Form L
Field Quality Control

QC Sample	Frequency	Acceptance Criteria	Corrective Action(s)
Trip Blank (Soil and Water)	One per cooler containing soil and/or water samples.	No detections at concentrations greater than ½ the reporting limit.	Review storage and handling procedures. Alter procedures as necessary. Qualify associated sample results per Region 1 guidance.
Field Duplicate (Soil)	One duplicate per ten samples collected.	RPD ≤50% for analytes present in both samples at concentrations greater than 2 times the reporting limit.	Review analysis procedures and similarity of samples.

Abbreviation:

RPD = relative percent difference

$$RPD = 100 \frac{|X_1 - X_2|}{\bar{X}}$$

Where X_1 and X_2 are values for sample 1 and 2, respectively, and \bar{X} is a sample mean.

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Form M Laboratory Quality Control

QC Item	Frequency	Methodology	Acceptance Criteria	Corrective Action
Laboratory Control Sample / Laboratory Control Sample Duplicate (8260B)	At the start of each analytical sequence (sample delivery group)	Reagent water is spiked with targeted compounds at specified concentrations and analyzed.	Reported concentrations within $\pm 30\%$ of true value.	Recalibrate instrument.
Laboratory Method Blank (8260B)	After the LCS	An aliquot of reagent water (aqueous samples) or a laboratory soil matrix preparation blank (soils) is analyzed. The reagent water is of the same source used for preparing standards, QC samples, and sample dilutions.	Free of target analyte contamination at or above the reporting limit.	Evaluate system for and eliminate sources of contamination and reanalyze blank. If sample carryover has occurred, reanalyze samples as appropriate.
Laboratory Instrument Blank (8260B)	After samples suspected of being highly contaminated	An aliquot of reagent water is analyzed.	Free of target analyte contamination at or above the reporting limit.	Evaluate system for and eliminate sources of contamination and reanalyze blank. If sample carryover has occurred, reanalyze samples as appropriate.
Internal Standards (IS) (8260B)	Each sample and laboratory QC sample	Measured amounts of certain compounds added after preparation of a sample.	Internal standard area counts must be between 50-200% of the initial calibration and CCV area counts.	Reanalyze sample, blank, or LCS.
Surrogate standards (SS) (8260B)	Each sample and laboratory QC sample	Measured amounts of certain compounds added during preparation of a sample.	Surrogate standard recoveries must be within 70-130 % limits.	Reanalyze sample, blank, or LCS for low surrogate recoveries; for high surrogate recoveries, reanalyze blank or LCS, and any sample with a detection.

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Form M (continued)
Laboratory Quality Control

QC Item	Frequency	Methodology	Acceptance Criteria	Corrective Action
Laboratory Method Blank (TO-15)	At the start of each analytical sequence (sample delivery group) and after samples suspected of being highly contaminated	A canister is pressurized with nitrogen or zero air, humidified, and analyzed.	Free of target analyte contamination at or above the reporting limit.	Evaluate system for and eliminate sources of contamination and reanalyze blank. If sample carryover has occurred, reanalyze samples with positive results for the contaminant < 5X blank concentration.
Internal Standard (IS) (TO-15)	Each sample	Measured amounts of certain compounds added after preparation of a sample.	Internal standard area counts for the CCV must be within 60-140% of the initial calibration, and for samples and QC samples, must be within 60-140% of the CCV area counts. Retention times of the internal standards must be within ± 0.33 minutes.	Reanalyze CCV, sample, blank, or LCS.
Laboratory duplicate (TO-15)	Each day of analysis	Two aliquots of the same sample are prepared and analyzed in the same manner.	Calculated only if the if the analyte is detected in both samples. RPD <25% for analytes detected in original and duplicate. Up to 10% of target analyte detections may exceed acceptance criteria. If the analyte is not detected in one sample, it must be detected in the duplicate at <5x the RL.	Repeat analysis.
Canister leak check (TO-15)	Before analysis	Measure the vacuum of the canister over a period of 30 seconds.	Vacuum must not increase more than 2 pounds per square inch atmospheric.	Determine and repair source of leak.

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Form M (continued)
Laboratory Quality Control

QC Item	Frequency	Methodology	Acceptance Criteria	Corrective Action
Holding Times	All samples	Analyze samples and any samples retained for corrective action before expiration of the holding time.	30 days (TO-15), 14 days (8260B)	Note exceedance on the Sample Delivery Group form.
Canister Preparation (TO-15)	All canisters	Canisters must remain in the laboratory for at least 24 hours before shipping to ensure they will hold vacuum.	Canisters with a vacuum measurement less than -28 in Hg must not be sent to the client.	Check each canister connection and tighten.
Canister Cleaning Certification (TO-15)	One per batch of nine canisters	Analyze batch certification canister using the appropriate analytical method SOP.	Target analytes must not be present above Reporting Limits.	Re-clean and re-certify entire batch of canisters.

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Form N

Data Management and Documentation

A field book will be used to compile information collected during the field work portion of the project, including sampling conditions, observations, and deviations from SOPs or this QAPP. When applicable, sampling forms will be used to document sampling activities.

At the analytical laboratory, samples are to be recorded in a permanently bound sample log-in notebook and a laboratory notebook, specific for each instrument. The laboratory will provide a full data package, which includes sample data, chains-of-custody, QA/QC narratives, internal standard area summaries, calibration summaries, surrogate recovery summaries, all applicable CLP or CLP-like forms and raw data, and data pertaining to blanks, matrix spikes, laboratory control samples, and duplicate samples. Full data packages will be provided for all samples analyzed. If demonstration of system cleanliness by analysis of an instrument blank is required, these records must be included in the data package. Records of the most recent quarterly verifications of the method limit of detection and limit of quantitation studies must be submitted with or prior to the data package.

Data will be provided by the laboratory in a digital format. Laboratory-supplied data, including the full data package, will be provided in an appendix to the pilot test report; the data validation report also will be included as an appendix to the report. Data will be stored in electronic format on The Johnson Company's secure local area network, which is backed up daily.

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Form O

Assessments and Response Actions

Field Tasks

During field activities, the field team is responsible for completing tasks in accordance with specified methods and SOPs. The Field Leader will be responsible for understanding the field program objectives and checking the completion of tasks. If a task is performed in a way that deviates from specified methods or SOPs, the field team will complete a Deviation Form describing the method or SOP deviation, the rationale for the deviation, and any corrective actions that may be required. An example deviation form is provided on the following pages. Deviation forms will be submitted as soon as possible to the QA Officer for review. If the deviation results in serious consequences for data integrity, the Project Manager may require corrective actions, such as collecting and analyzing additional samples.

If any unexpected circumstances are encountered in the field, the Project Manager will be contacted before the field activity proceeds. Field tasks will be documented by field staff and overseen in the field by the Field Leader. The Field Leader will be responsible for carrying out corrective actions as directed by the Project Manager. The Project Manager may consult with the client, USEPA, MassDEP, or other stakeholders before providing direction regarding corrective actions or changes to the scope of work.

Laboratory tasks

The analytical laboratory is responsible for ensuring that all lab tasks are completed in accordance with methods and SOPs. The laboratory must maintain its NELAC certification throughout the course of the project.

Modifications to QAPP

Major modifications to this QAPP must have prior approval by the USEPA Project Manager.

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THE JOHNSON COMPANY, INC.

100 State Street, Suite 600
Montpelier, Vermont 05602

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JCO File #:

*Quality Assurance Unit
Record of
(Check One)*

- [] A. *Deviation from Protocol or Standard Operating Procedure*
or
[] B. *Notation, Correction and Documentation of Unforeseen Circumstances*

Ref: 40 CFR § 160.81, § 160.33 and § 160.35 and SOP-JCO-018

Date(s) of Occurrence:

Study Designation:

Study Location:

Test substance:

CAS No.:

Study Sponsor:

Study phase (or segment):

Site of problem:

Scientist, engineer or technician:

Initials: _____ Date: _____

Findings:

Weather: _____ °F; Sky: Clear, Partly Cloudy, Cloudy, Fair, Rain, Snow; Wind-

List: Personnel, Visitors, Contractors:

Equipment (e.g. Permeameter, Data Logger, Drill rig, Dozer):

Protocol title, date and section number:

Standard Operating Procedure title:

SOP No:

Type of deviation (inadvertent or planned):

Nature of deviation or unforeseen circumstance:

Observations:

Problems:

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THE JOHNSON COMPANY, INC.
100 State Street, Suite 600
Montpelier, Vermont 05602

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JCO File #:

Continuation Sheet

Initials: Date:

(Instruction: Number paragraphs consistent with the numbers of items listed under Procedure A or B in SOP-JCO-018. Begin with No. 2. Sheet 1 of this report addresses Item No. 1.)

FORM.005

PRIVILEGED AND CONFIDENTIAL DO NOT REPRODUCE OR DISTRIBUTE

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Form P

Project Reports

A pilot test report will be produced and presented to the USEPA within 90 days of completion of the pilot testing. The report will provide a description of the following: methods used for soil, extracted soil vapor, and soil vapor condensate sampling; vapor extraction test point and observation point installation; and performance of the step and constant rate vacuum tests. The report will include estimates of ROI and *ex situ* flow velocity of extracted soil vapor for the extraction test points at different applied vacuums. Potential interference by subsurface structures and anisotropy in extraction point ROI will be identified. Figures will be included that depict vapor extraction test point and observation point locations. Field and laboratory analytical data will be tabulated. The appendices will include laboratory narratives, field deviation reports, and completed field forms that have not otherwise been summarized.

The report will present recommendations for design of a full-scale soil vapor extraction (SVE) and off-gas treatment system, if the pilot test results confirm SVE as an effective remedial action component at the Property.

The final pilot test report (including summary tables, graphics, and appendices) will be provided in hard copy and electronic format to the USEPA, MassDEP, and the client.

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Form Q

Field Data Evaluation

Field notes, sampling forms, and deviation forms will be reviewed for errors and omissions by the sampler, Field Leader, and QA Officer.

The QA Officer will evaluate the field records for consistency and review pertinent QC information on these records. Deviation reports will be reviewed for consistency with field records to determine if appropriate corrective actions have been completed and if these deviations impact project goals. Field notes will be compared to chain-of-custody documents and laboratory reports to verify that all samples intended for laboratory analysis were sent to the laboratory and analyzed. A field data validation report will be included as an appendix.

Field data forms that have not otherwise been summarized in the final report will be included in the appendix of the final report. All original field forms will be electronically filed by The Johnson Company and retained in accordance with Article XXVI of the Wells G&H Consent Decree entered in the matter of United States vs. Wildwood Conservation Corporation *et al* (Civil Action 91-11807-MA) entered 10/9/91.

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Form R

Laboratory Data Evaluation

Field analytical data will be used solely for screening; therefore, no comparison with laboratory analytical results will be performed. Field analytical data will be evaluated by the Field Leader and the QA Officer based on the observed performance of the screening equipment and any required deviations from the applicable SOP.

Analytical data generated by the analytical laboratory will be reviewed for data completeness by a subcontracted data validator from Phoenix Chemistry Services (PCS) of North Ferrisburg, Vermont. The Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses (12/96) and the National Functional Guidelines for Superfund Organic Methods Data Review (06/08) will be used for soil and soil vapor condensate samples. These guidelines do not address air sample results; therefore, the review by PCS will be conducted according to the USEPA Region 2 guidance entitled "USEPA Hazardous Waste Support Branch: Validating Air Samples, Volatile Organic Analysis Of Ambient Air in Canister By Method TO-15 (SOP # HW-31, Revision #4, October 2006)" and will include checking holding times, proper chain-of-custody documentation, acceptable detection limits, internal standard recoveries, and laboratory control sample recoveries.

Data validation is a process by which laboratory-reported data are subjected to a comprehensive, technically oriented evaluation by personnel experienced in the analysis and review of sample data from environmental matrices. Non-compliance with the method specifications may be noted where relevant.

During the validation process, laboratory data are verified against all available supporting documentation. Based on this evaluation, qualifier codes may be added, deleted, or modified by the data validator. In a Tier III assessment, raw data is examined in detail to check calculations, compound identification, and/or transcription errors. Validated results are either qualified or unqualified; if results are unqualified, this means that the reported values may be used without reservation. Final validated results are annotated with the qualification codes defined in the EPA Region I Functional Guidelines.

The data validation will use the following criteria to evaluate the data: precision, accuracy, and completeness, as detailed below.

- **Accuracy:** The amount of agreement between the true value of a parameter and the measured value. Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It therefore reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike or standard. To assess the accuracy of the laboratory measurements, the trueness of instrumental calibrations will be evaluated by assessment

of linearity and differences of daily calibrations to the linearity measurement; the percent recovery will be calculated for all spiked analytes, including internal standards, surrogates, and target analytes; and the accuracy of the analytical system near the detection limits will be taken into account. The control limits for percent recovery of spike compounds and surrogates are listed in the laboratory SOP corresponding to the specific analytical method used for analysis.

- **Precision:** The measurement of the agreement between samples from the same population. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Precision can be expressed as the relative standard deviation (RSD) between independent samples or as the relative percent difference (RPD) between duplicate samples.
- **Completeness:** The measure of the amount of validated data obtained compared to that which was expected to be obtained. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of a data set. For completeness requirements, valid results are all results not qualified with an “R” flag. An “R” flag placed on the data by the data validator indicates that the data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria. Results with an “R” flag that are replaced by other analyses, as in the case of diluted analyses, are not included in the assessment of completeness.

The results of each component of the data review will be summarized in the final report. A table summarizing the QC results will be included, as well as any revisions or qualifiers deemed necessary.

Where appropriate and/or where advised by the analytical laboratory, data may be accepted as is, accepted but qualified, or rejected (“R”) if it is determined not to be of sufficient quality for this project. Data validation, acceptance, and qualification decisions will be made by the QA Officer.

Title: QAPP for Vapor Extraction Pilot Test
Site Name: UniFirst Property
Site Location: Woburn, Massachusetts

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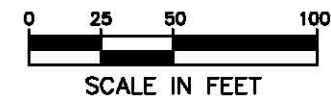
Form S

Data Usability and Project Evaluation

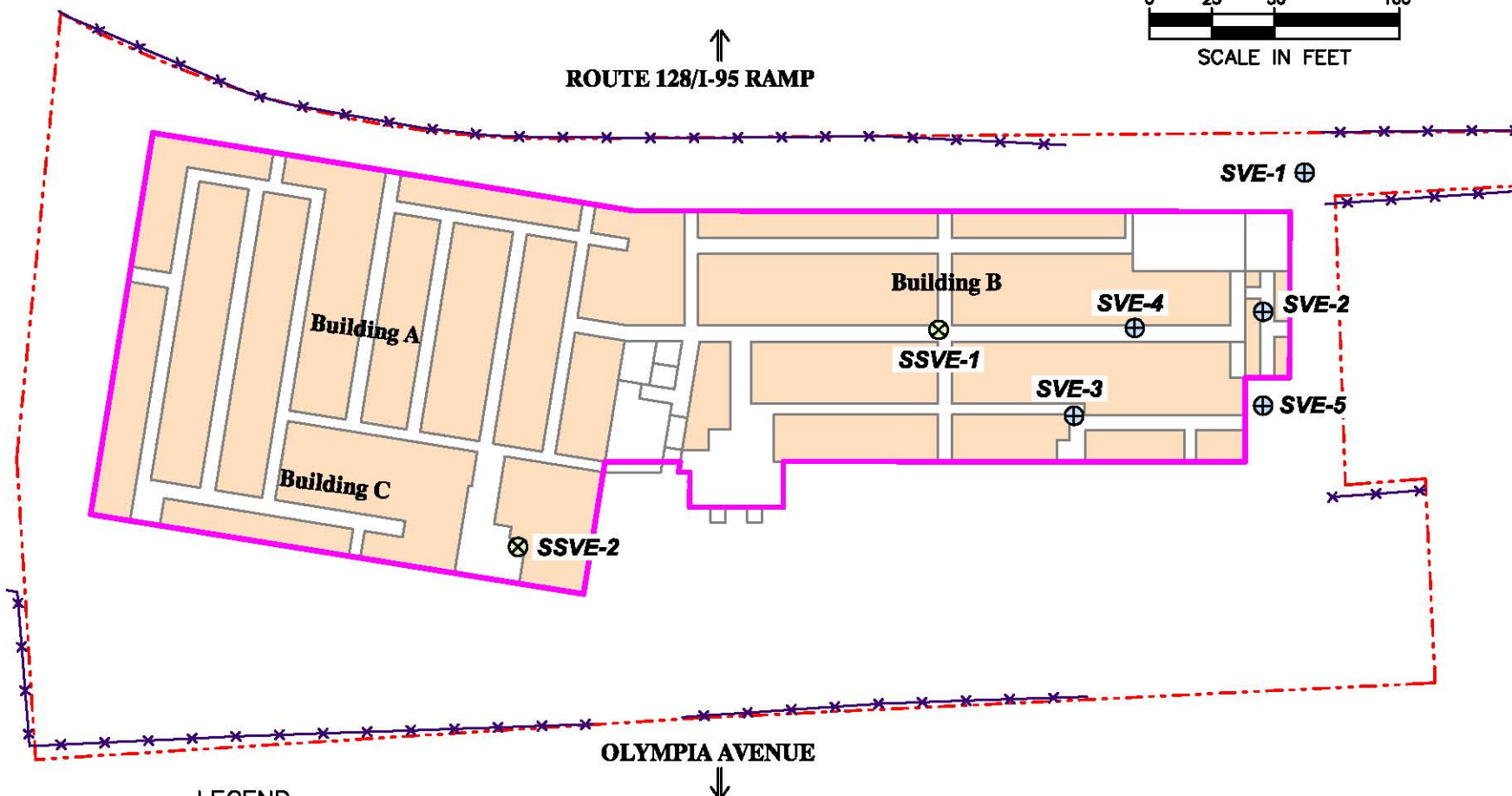
The results of the data validation will be used to prepare a data usability assessment, which will be included in the final report. The data usability assessment will summarize the findings of the data validation and present the implications to the pilot test objectives.

Deviations or specific data qualifications identified by PCS will be discussed in terms of their effect on the pilot test decision-making process. Data usability will be determined based on the data verification and data validation processes described on Forms Q and R. If deviations are identified that may cause data to be unusable, additional samples may be collected and screened/analyzed to provide useable data. If no significant deviations are identified, the data will be used to complete the report as specified on Form P.

FIGURES



↑
ROUTE 128/I-95 RAMP



LEGEND

- SSVE-1** ⊗ PROPOSED SUB-SLAB VAPOR SAMPLING POINT
- SVE-1** ⊕ PROPOSED SOIL VAPOR EXTRACTION PILOT TEST POINT
- BUILDING FOOTPRINT
- - - SITE BOUNDARY
- APPROXIMATE STORAGE AREA FOOTPRINT
- x - x - x - x - FENCELINE

NOTE:

PROPOSED SAMPLING LOCATIONS ARE APPROXIMATE AND MAY BE ADJUSTED FOLLOWING FIELD REVIEW.

SOURCE:

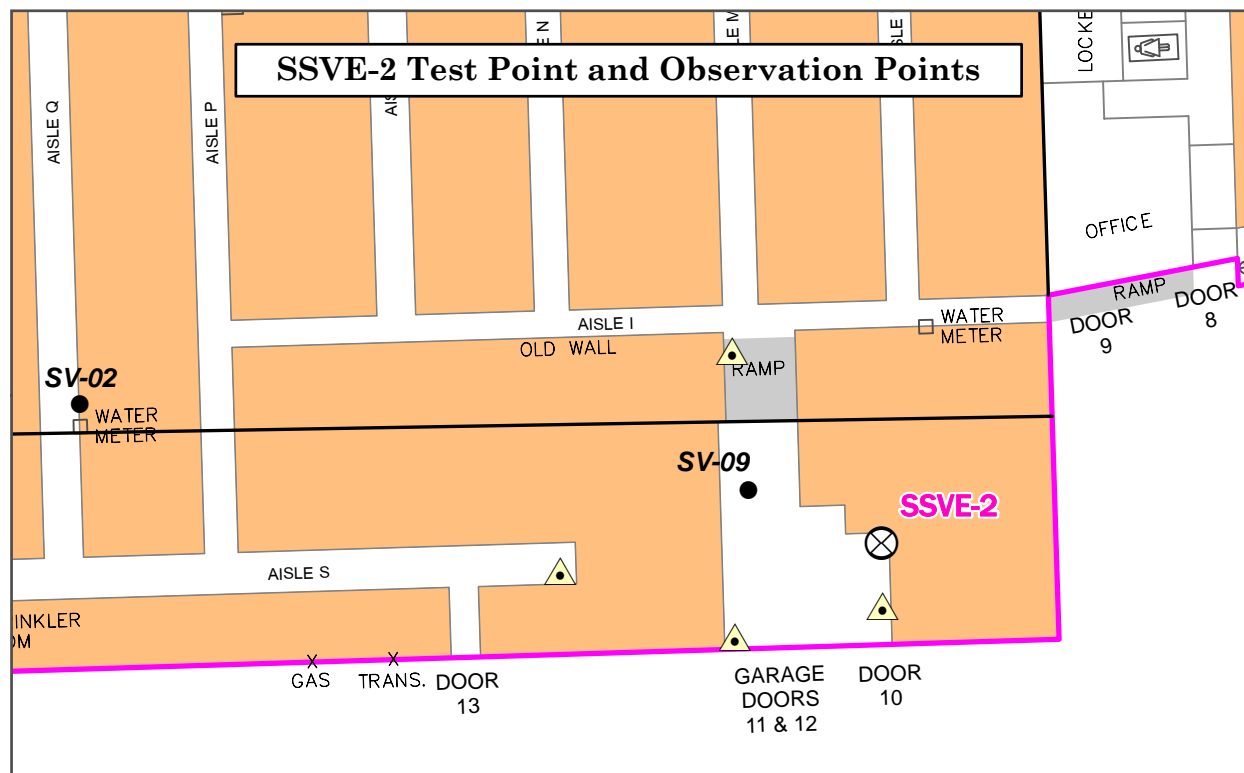
UNDATED LAYOUT DRAWING OF THE EXTRA SPACE STORAGE OPERATION PROVIDED TO UNIFIRST CORP.


**FIGURE 1: PILOT TEST POINT LOCATIONS
UNIFIRST CORPORATION
WOBURN, MASSACHUSETTS**





100 State Street, Suite 600
Montpelier, VT 05602
(802) 229-4800


Drawn by: TJK Date: 07/03/12
Chk'd by: BLL Date: 07/03/12
Scale: As Shown Project: 1-2114-2





SSVE-1  Proposed Sub-Slab Vapor Extraction Point

SV-09  Previous Sub-Slab Soil Vapor Sampling Location

 Proposed Small-Diameter Slab Penetration for Monitoring Pressure

 Building Footprint

 Interior wall location (may indicate presence of sub-slab footings)

 Approximate Storage Area Footprint

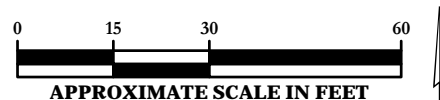


FIGURE 3: SSVE POINT
AND OBSERVATION POINTS LOCATIONS
UNIFIRST PROPERTY: WOBURN, MASSACHUSETTS



100 State Street, Suite 600
Montpelier, VT 05602

Drawn by: DPB	Date: 04/18/11
Chk'd by: BLL	Date: 04/28/11
App'd by: BLL	Date: 04/28/11
Scale: 1" = 30'	Project: 1-2114-2

APPENDICES
(PROVIDED ON CD)

APPENDIX 1: ANALYTICAL METHOD SOPS

APPENDIX 2: PROJECT SAMPLING SOPS

Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)

References: **Method 8260 B**, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December 1996.

Method 5035, Closed System Purge & Trap and Extraction for Volatile Organics in Soil and Waste Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

Method 5030B, Purge & Trap for Aqueous Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December, 1996.

1. Scope and Application

Matrices: Method 8260 is used to determine volatile organic compounds in a variety of solid waste matrices. This method is applicable to nearly all types of samples, regardless of water content, including various air sampling trapping media, ground and surface water, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments.

Definitions: Refer to Alpha Analytical Quality Manual.

The following compounds can be determined by this method:

8260B LIST OF ANALYTES		
dichlorodifluoromethane	carbon tetrachloride	isopropylbenzene
chloromethane	1,2-dichloroethane	1,4-dichloro-2-butane
vinyl chloride	benzene	1,1,2,2-tetrachloroethane
chloroethane	trichloroethene	trans-1,4-dichloro-2-butene
bromomethane	1,2-dichloropropane	1,2,3-trichloropropane
trichlorofluoromethane	bromodichloromethane	n-propylbenzene
ethyl ether	dibromomethane	bromobenzene
acetone	4-methyl-2-pentanone	2-chlorotoluene
1,1-dichloroethene	cis-1,3-dichloropropene	1,3,5-trimethylbenzene
carbon disulfide	toluene	4-chlorotoluene
methylene chloride	trans-1,3-dichloropropene	tert-butylbenzene
acrylonitrile	ethyl-methacrylate	1,2,4-trimethylbenzene
methyl-tert-butyl ether	1,1,2-trichloroethane	sec-butylbenzene
trans-1,2-dichloroethene	2-hexanone	p-isopropyltoluene
1,1-dichloroethane	1,3-dichloropropane	1,3-dichlorobenzene
vinyl acetate	tetrachloroethene	1,4-dichlorobenzene
2-butanone	chlorodibromomethane	n-butylbenzene
2,2-dichloropropane	1,2-dibromoethane	1,2-dichlorobenzene
cis-1,2-dichloroethene	chlorobenzene	1,2-dibromo-3-chloropropane
chloroform	1,1,1,2-tetrachloroethane	1,2,4-trichlorobenzene
bromochloromethane	ethyl benzene	hexachlorobutadiene
tetrahydrofuran	p/m xylene	naphthalene
1,1,1-trichloroethane	o xylene	1,2,3-trichlorobenzene
1,1-dichloropropene	styrene	bromoform

There are various techniques by which these components may be introduced into the GC/MS system. Purge-and-trap, by Methods 5030 (aqueous samples) and 5035 (solid and waste oil samples), is the most commonly used technique for volatile organic analytes. However, other techniques are also appropriate and necessary for some analytes. One technique is direct injection of an aqueous sample (concentration permitting).

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph/mass spectrometers and in the interpretation of mass spectra and their use as a quantitative tool. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability, analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the Quality Assurance Officer and/or Laboratory Director on a case-by-case basis.

2. Summary of Method

The volatile compounds are introduced into the gas chromatograph by the purge-and-trap method or by direct injection. The analytes are introduced to a narrow-bore capillary column for analysis. The Gas Chromatograph (GC) is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced to the GC.

Analytes eluted from the capillary column are introduced into the mass spectrometer via a direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard, comparing sample response to the calibration standards.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

Table 1 lists our typical reporting limits.

4. Interferences

- 4.1** Impurities in the purge gas, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be free from contamination under the conditions of the analysis. Running laboratory reagent blanks as described in Section 10.3 and 9.1 demonstrates the system is free of contamination. The use of non-Teflon plastic tubing,

non-Teflon thread sealants, or flow controllers with rubber components in the purge and trap system must be avoided.

- 4.2** Sample contamination occurs by diffusion of volatile organics (particularly fluorocarbons and methylene chloride) through the septum seal into the sample during shipment and storage. A trip blank or a field reagent blank prepared from reagent water and carried through the sampling and handling protocol serves as a check on such contamination.

4.2.1 Storage blanks shall be analyzed if contamination is suspect. If contamination is confirmed by positive detections in the sample storage blanks, all data from samples contained in the relative refrigerator or freezer shall be evaluated for possible contamination. If the samples contain suspected contamination, the Client Services department shall be notified in order to contact the necessary clients regarding the contamination. Samples shall be reanalyzed if so desired by the client. If suspected contamination is not confirmed by storage blanks, no further action shall be pursued concerning said blanks. It is recommended that further action be taken to determine the possible cause of suspected contamination.

- 4.3** Contamination by carry-over can occur whenever high level and low level samples are sequentially analyzed. Whenever a highly concentrated sample is being encountered, it should be followed by an analysis of reagent water (instrument blank) to check for potential contamination. If carry-over is suspected, then numerous instrument blanks may be required; additionally all affected samples are rerun for confirmation.. In case of severe contamination, preventive maintenance of the entire system may be required.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, 1,4-dichlorobenzene, 1,2-dichloroethane, hexachlorobutadiene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, chloroform, 1,2-dibromoethane, tetrachloroethene, trichloroethene, and vinyl chloride. Pure standard materials and stock standard solutions of these compounds should be handled in a hood. A NIOSH/MESA approved toxic gas respirator should be worn when the analyst handles high concentrations of these toxic compounds.

- 5.1** Lab coats, safety glasses, and gloves must be worn when handling samples, standards, or solvents.
- 5.2** All stock solution standard preparation must be performed in the volatiles hood. Initial calibration, continuing calibration, laboratory control sample and client sample dilutions do not need to be performed in the hood.
- 5.3** All expired standards must be placed into the waste bucket in the lab, for future disposal. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing Methanol must be stored in the flammables cabinet.

6. Sample Collection, Preservation, Storage, Shipping and Handling

6.1 Sample Collection and Preservation

6.1.1 Aqueous Samples

Grab samples are collected in standard 40mL amber glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two or more VOA vials should be filled per sample location. EPA Method 8260 requires that samples be acidified to eliminate the possibility of biological degradation. Unless otherwise directed for project-specific reasons, all VOA vials are delivered to the client with approximately 2 – 4 drops of 1:1 HCl added to the vial, which is sufficient to adjust the pH of the sample to < 2. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Fill the sample vial to the point of overflowing so that no headspace is contained within. Samples must be introduced into the vials gently to reduce agitation, which might drive off volatile compounds or cause loss of the HCl preservative.

Seal the bottle so that no air bubbles are in the VOA vial. If preservative has been added, shake vigorously for one minute. Invert the bottle and tap to check for air bubbles. Recollect the samples if any air bubbles are present.

Maintain the hermetic seal on the VOA vial until time of analysis.

6.1.2 Soil Samples

The recommended sampling method for soil samples is EPA 5035. Method 5035 provides for two distinct sampling procedures, depending on the required reporting limits and suspected or known concentration levels of target analytes. These methods are referred to as the High Level and Low Level methods. Both are listed below, but depending on the samples only one of the methods may be required. If concentration levels are unknown, it is recommended that samples be collected using both procedures. The Lab will analyze the high level sample first, followed by the low level sample if the results from the high level analysis show that the sample is clean or contains analytes at low levels. The typical reporting levels of the two methods are listed in Table 1.

6.1.2.1 High Level Soil Samples

Collect sample in a standard 40mL amber glass screw-cap vial with Teflon lined silicon septa (VOA vial). The vial is provided containing 15mL of Purge and Trap Grade methanol, and is labeled and weighed prior to addition of sample. Record the weight of the vial with methanol on the vial label. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Approximately 15g of soil is added to the vial in the field, making sure that the sample is completely covered by the methanol.

Maintain the hermetic seal on the VOA vial until the time of analysis.

An additional sample of the soil must also be obtained (without methanol) to be used for the determination of soil moisture content to allow for the calculation of the dry weight results, and to calculate the methanol dilution effect. (See Sections 11.1.2.2.2 and 11.1.2.2.3)

6.1.2.2 Low Level Soil Samples

Collect sample in a standard 40mL amber glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two samples should be taken per sample location. Vials are provided containing a magnetic stirring bar and 5 mL of either 200g/L sodium bisulfate solution or water, prepared by a certified vendor. These vials are labeled and weighed prior to addition of sample. Record the weight of the vial with the stirring bar and preservative on the vial label.

Approximately 5g of soil is added to the vial in the field, making sure that the sample is completely covered by the sodium bisulfate solution or water.

Maintain the hermetic seal on the VOA until the time of analysis.

6.2 Sample Handling and Storage

Document client specific sample handling, preservation and collection criteria in the project file. The laboratory Log-in staff documents sample temperature at the time of receipt.

Record deviations from this SOP or client specific criteria on the chain of custody form.

Record holding time exceedence, improper preservation and observed sample headspace on the nonconformance report form.

6.2.1 Aqueous Samples

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel note on the sample delivery group form when samples received at the laboratory are not within the temperature criteria. If more than one vial is received for a sample the vials are stored in separate refrigerators. Storing the vials apart provides a useful check if laboratory contamination of a sample is suspected. Samples must be analyzed within 14 days of collection. Unpreserved samples requiring aromatic analysis must be analyzed within 7 days of collection.

6.2.2 High Level Soil Samples

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel note on the nonconformance report form when samples received at the laboratory are not within the temperature criteria.

6.2.3 Low Level Soil Samples

Ice or refrigerate samples preserved with water or sodium bisulfate from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Samples preserved with water are to be immediately frozen after sampling. Sample receiving personnel note on the nonconformance report form when samples received at the laboratory are not within the temperature criteria.

6.3 Sample Shipping

Samples requiring shipment to the laboratory are shipped in ice-packed coolers via an overnight delivery service in accordance with applicable Department of Transportation regulations.

7. Equipment and Supplies

7.1 Purge and Trap System (For Aqueous samples and High Level Soils): The purge-and-trap system consists of two separate pieces of equipment: a purging device (autosampler) (Varian Archon/8100, Tekmar Solatek, EST Centurion) coupled to the desorber (concentrator) (Tekmar Velocity or EST Encon).

- 7.1.1** Purge gas = Helium, analytical grade (99.999%).
- 7.1.2** The purging device is configured with 25 mL sample purge tubes, and the helium purge gas is introduced at the bottom of the water column as finely divided bubbles
- 7.1.3** The trap used in the desorber is typically a Supelco "K" trap. Different traps may be used if equivalent performance is demonstrated.
- 7.1.4** The desorber is capable of rapidly heating the trap to 260°C. The trap is not heated above manufacturer's specifications

7.2. Purge and Trap System (For Low Level Soil Samples): The purge and trap system consists of two separate pieces of equipment: a purging device (autosampler) coupled to the desorber (concentrator) (Varian Archon/8100, Tekmar Solatek, EST Centurion with EST Encon, Tekmar Velocity, or equivalents).

- 7.2.1.** Purge gas = Helium, analytical grade (99.999%).
- 7.2.2.** The autosampler purging device is a closed system, designed to accept the 40mL VOA vials. The VOA vial, containing the soil sample, water (or sodium bisulfate), and stirring bar is placed into the autosampler tray. The instrument automatically adds reagent water, internal standards, and surrogates to the unopened VOA vial. The vial is heated to 40 °C, and the helium purge gas is introduced into the aqueous portion to purge the volatile components onto the trap.
- 7.2.3.** The trap used in the desorber is typically a Supelco "K" trap. Different traps may be used if equivalent performance is demonstrated.
- 7.2.4.** The desorber is capable of rapidly heating the trap to 260 °C. The trap is not heated above manufacturer specifications.

7.3 Gas Chromatography/Mass Spectrometer/Data System:

7.3.1 Gas Chromatograph, Hewlett Packard 6890/7890 or equivalent: An analytical system complete with a temperature-programmable gas chromatograph with appropriate interface for sample introduction device. The system includes all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source of the GC/MS system.

7.3.2 Gas Chromatographic Columns:

- 7.3.2.1** Column 1: Restek 502.2, 40 meter, 0.18mm ID, or equivalent.
- 7.3.2.2** Column 2: Restek 502.2, 60 meter, 0.25mm ID, or equivalent.
- 7.3.2.3** Column 3: Restek 502.2, 20 meter, 0.18mm ID, or equivalent

7.3.3 Mass Spectrometer, Hewlett Packard 5973/5975 or equivalent: Scanning from 35 to 300 amu every 2 seconds or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for 4-Bromofluorobenzene (BFB) which meets all of the criteria in Table 3, when 50ng of the GC/MS tuning standard (BFB) are injected through the GC.

7.3.4 Data System: Hewlett-Packard EnviroQuant software is used for data acquisition, and allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program.

Thruput Target 4.12 software is used for data processing, and allows searching of any GC/MS data file for ions of a specified mass, and plotting such ion abundances versus time or scan-number.

The most recent version of the EPA/NIST Mass Spectral Library is loaded onto the Target data system.

7.4 Wiretrol or Microsyringes: 10µL - 1,000µL.

7.5 Syringes: 5mL, 10mL, or 25mL, glass with Luerlock tip.

7.6 Balances: Top-loading, capable of weighing 0.1g.

7.7 Vials: 2mL, 4mL.

7.8 Disposable Pipets.

7.9 Volumetric Flasks: Class A, appropriate sizes, with ground-glass stoppers.

7.10 Eppendorf Pipets

8. Reagents and Standards

Reagent grade organic chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all organic reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

Great care must be taken to maintain the integrity of all standard solutions. Standards in methanol are stored at -10°C or less, in amber vials with PTFE-lined screw-caps.

8.1 Organic-free Reagent Water:

All references to water in this method refer to organic-free reagent water, which is tap water passed through activated carbon and air bubbled through.

8.2 Methanol:

Purge and Trap Grade or equivalent. Store in flammables cabinet.

8.3 Stock Solutions:

All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled amber screw-cap vial with minimal headspace. The expiration date of the stock solution is either the vendor specified expiration date or 6 months from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 4.

8.4 Intermediate Standards: Intermediate standards are prepared volumetrically by diluting the appropriate stock standard(s) with methanol. Initial Calibration solutions expire 2 months from the date of preparation. If the Intermediate Standards are used as a second source to verify a valid Initial Calibration solution, there is no expiration date.

8.4.1 Internal Standard Solutions:

The internal standards are fluorobenzene, chlorobenzene- d_5 , and 1,4-dichlorobenzene- d_4 . The intermediate I.S. solution is prepared by diluting the stock solution(s) with methanol to a concentration of 100 $\mu\text{g/mL}$. The appropriate amount of I.S. solution is added to the water or soil sample or QC sample to achieve a final concentration of 100 ng/sample or standard. Internal standard is added at the same concentration to all standards, samples, and QC samples.

8.4.2 Surrogate Standard Solutions:

The surrogate standards are dibromofluoromethane, 1,2-dichloroethane- d_4 , Toluene- d_8 , and 4-bromofluorobenzene. The intermediate surrogate solutions is prepared by diluting the stock solution(s) with methanol to a concentration of 100 $\mu\text{g/mL}$. The appropriate amount of surrogate solution is added to the water or soil sample or QC sample to achieve a final concentration of 100 ng/sample.

8.4.3 Target Compound Solutions:

The target analytes routinely reported by this method are listed in Table 4. The intermediate target compound solutions are prepared by diluting the stock solution(s) with methanol. This set of solutions, at concentrations of 200 $\mu\text{g/mL}$, is used for preparation of the calibration standards at the concentrations listed in Table 4.

8.4.4 4-Bromofluorobenzene (BFB) Tune solution:

A solution containing BFB at a concentration of 25 µg/mL is prepared by volumetrically diluting the BFB stock solution. 2 µL of this solution is direct-injected or purged into the GC/MS system to verify system performance prior to any standard or sample analysis.

8.5 Calibration Standards:

There are two types of calibration standards used for this method – initial calibration standards and calibration verification standards.

8.5.1 Initial Calibration Standards:

Initial calibration standards are prepared at the levels listed in Table 4. Prepare these solutions in organic-free reagent water. The standards correspond to the range of concentrations found in typical samples and do not exceed the working range of the GC/MS system. Initial calibration should be mixed from fresh stock standards and dilution standards when generating an initial calibration curve. Some machines use only 7 points initial calibration, instead of 8.

8.5.2 Continuing Calibration Verification Standards:

The continuing calibration verification standard, or calibration check standard, is at the same concentrations as the level 3 initial calibration standard. This standard is run at the beginning of each analytical sequence, following the BFB tune standard, to verify system performance. This standard is made from a second source than the Initial Calibration Standards

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

Blank samples must be matrix specific. i.e. methanol samples need to have methanol in the blank; sodium bisulfate samples need to have a sodium bisulfate blank analyzed; TCLP samples need a TCLP blank.

Analyze a matrix-specific blank each day prior to sample analysis to demonstrate that interferences from the analytical system are under control. The blank must contain the internal standards and surrogates.

Analyze the reagent water blank from the same source of water used for preparing the standards, QC samples and making sample dilutions. The method blank must not contain any target analytes at or above the compound reporting limits.

9.2 Laboratory Control Sample (LCS)/ Laboratory Control Sample Duplicate (LCSD)

A LCS/LCSD pair is analyzed at the beginning of each analytical sequence. Since the LCS contains the same compounds at the same concentrations as the continuing calibration check

standard, the same analysis is used to satisfy both QC elements. The LCS/LCSD acceptance criteria are based on in-house control limits..

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.4

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4.

9.5 Matrix Spike/ Matrix Spike Duplicate

Upon Client Request, a matrix spike/matrix spike duplicate pair may be analyzed with each batch of 20 or less samples. The MS/MSD are sample aliquots spiked with the target compounds at the same concentration as the continuing calibration standard. The MS/MSD acceptance criteria are based on in-house control limits. If the MS/MSD does not meet the criteria, but the LCSD does, the failure may be attributed to sample matrix. Report the MS/MSD, including a narrative sheet for inclusion with the client report.

9.6 Laboratory Duplicate

Not applicable.

9.7 Method-specific Quality Control Samples

9.7.1 Internal Standards

Area counts of the internal standard peaks in all samples and QC samples must be between 50-200% of the areas of the internal standards in the QC check standard.

If any individual percent recovery falls outside the range, that parameter has failed the acceptance criteria. For calibration standards, CCVs, LCS/LCSD or blanks the internal standard must be within the range for data to be reported to the clients. For samples, matrix spikes and duplicates: if the data is not within the range, the sample is rerun to confirm that the failure is due to sample matrix. A nonconformance report form is completed to ensure client notification and reporting if matrix effect is confirmed.

9.7.2 Surrogates

Surrogates are added to each field sample and QC sample. The laboratory must evaluate surrogate recovery data from individual samples versus the surrogate control limits developed by the laboratory. The surrogate acceptance criteria are listed in Table 2.

9.8 Method Sequence

In a 12-hour period, the typical analytical sequence is as follows:

- BFB
- QC Check Standard/Laboratory Control Sample/LCSD
- Method Blank
- Samples
- MS/MSD (upon Client request, may be run anytime after the Method Blank)

10. Procedure

10.1 Equipment Set-up

Typical instrument operating conditions are listed below. Alternate conditions are allowed, as long as method performance criteria can be met.

10.1.1 GC Conditions:

Temperature 1:	35°C	Carrier gas:	Helium, 99.999%
Hold Time 1:	4 minutes	Carrier mode:	Constant flow
Ramp 1:	6°C/minute	Carrier flow:	1 mL/minute
Temperature 2:	150°C		
Hold Time 2:	0 minutes		
Ramp 2:	8°C/minute		
Temperature 3:	220°C		
Final Time:	1 minute		

10.1.2 MS Conditions:

Mass scan range:	35 – 260 amu -
Scan time:	0.5 minutes/scan -
Source temperature:	230°C -

10.1.3 Velocity Concentrator Purge and Trap Conditions:

Purge time:	11 minutes -
Dry purge:	2 minutes -
Desorb preheat:	250°C -
Desorb temp:	255°C -
Desorb time:	2 minutes -
Bake temp:	290°C -
Bake time:	10 minutes -

10.1.4 Encon Concentrator Purge and Trap Conditions:

Purge time:	11 minutes -
Dry purge:	1 minute -
Desorb preheat:	245°C -
Desorb temp:	255°C -
Desorb time:	1 minute -
Bake temp:	270°C -
Bake time:	10 minutes -

10.2 Initial Calibration

- 10.2.1** The initial calibration is performed at the 7 (or 8, depending upon the analytical capacity of the instrument) concentration levels listed in Table 4. The calibration is performed using instrument conditions listed in Section 10.1.

BFB must be analyzed prior to analysis of the initial calibration standards, and must pass the criteria listed in Table 3. The mass spectrum of BFB should be acquired in the following manner:

- (1) - Three scans (the peak apex scan, the scan immediately preceding the apex and the scan immediately following the apex) are acquired and averaged.
- (2) - Background subtraction is performed using a single scan of no more than 20 scans prior to the elution of BFB.

This is done automatically with the ThruPut Target software.

- 10.2.1.1 Low Level/High Level Soil Curve on Archon or Centurion:** To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 50mL volumetric flask using a microsyringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, then gently fill a 5mL syringe with standard and transfer to a 40mL VOA vial containing a magnetic stir bar. Load the vial onto Archon Autosampler.

- 10.2.1.2 Aqueous/High Level Soil Curve on Solatek or Centurion:** To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 100mL volumetric flask using a microsyringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, then gently fill a 40mL VOA vial to the top. Load the vial onto the Autosampler.

- 10.2.2** Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in Section 10.1. The same operating conditions are used for calibration and sample analyses. Create the analytical sequence using the HP Enviroquant data acquisition software.

Relative Response Factors: The internal standard calibration technique is used. In each calibration standard, calculate the relative response factor for each analyte and the relative standard deviation (RSD) of the response factors using the Target data processing software. The response factors are calculated using the areas of the characteristic (quantitation) ion for each target analyte and internal standard. The calculations are performed automatically using the Target software, using the formulae listed in Alpha's Quality Manual.

- 10.2.3 Initial Calibration Criteria:** The following sections outline the method acceptance criteria for an initial calibration curve. All criteria must be met for the calibration to be deemed acceptable, and for sample analysis to proceed.

10.2.3.1 System performance check compounds (SPCCs):

Five compounds (the System Performance Check Compounds, or SPCCs) must meet minimum response factor criteria. These compounds are: chloromethane, 1,1-dichloroethane, bromoform, chlorobenzene, and 1,1,2,2-tetrachloroethane. These

compounds are monitored to demonstrate system performance. Possible causes of low response for these analytes are listed below.

Chloromethane response may be low if the purge flow is too fast.

Bromoform response may be low if the purge flow is too slow. Cold spots and/or active sites in the transfer lines may adversely affect response as well.

1,1,2,2-Tetrachloroethane and 1,1-dichloroethane response may be low in there are contaminated transfer lines in the purge-and-trap system, or the trap may need to be replaced.

The minimum mean response factors for the volatile SPCCs are as follows:

Chloromethane	0.10
1,1-Dichloroethane	0.10
Bromoform	0.10
Chlorobenzene	0.30
1,1,2,2-Tetrachloroethane	0.30

10.2.3.2 Relative Standard Deviation Criteria: If the RSD for each target analyte is less than or equal to 15%, then the response for this compound is considered linear over the calibration range and the mean calibration factor can be used to quantitate sample results. If the 15% RSD criterion is not met for an analyte, linear regression may be used if $r^2 \geq 0.995$. The calibration may be repeated for any compounds that fail, or a calibration curve must be generated for this compound and used for sample quantitation.

Six of the target analytes are designated as Calibration Check Compounds (CCCs). For these compounds, listed below, the %RSD must be below 30%. If this criterion is not met for all 6 compounds, the calibration curve is invalid and cannot be used. If the %RSD is less than or equal to 15%, the mean RF is used for sample quantitation. If the %RSD is between 15 and 30%, linear regression may be used for sample quantitation. The CCCs are:

1,1-Dichloroethene	Toluene
Chloroform	Ethylbenzene
1,2-Dichloropropane	Vinyl chloride

If an RSD of greater than 30% is measured for any CCC, then corrective action to eliminate a system leak and/or column reactive sites is necessary before reattempting calibration.

10.2.4 Evaluation of Retention Times: The relative retention times used for identification of target analytes are ± 0.06 RRT (Relative Retention Time) units, based on the most recent standard run. It has been determined that these limits work well, being wide enough to eliminate false-negative results while being tight enough to eliminate false positive results. Due to the selectivity of the mass spectrometer, compound identification is more definitive than when using a less selective detector.

10.3 Equipment Operation and Sample Processing

The same GC, MS, and Purge and Trap conditions used for the initial calibration must be employed for sample analysis. After verification of system performance by analysis of BFB, the continuing calibration standard and method blank, samples are analyzed and processed as described below.

10.3.1 Analysis of Samples

Retrieve sample VOA vials from the sample bank refrigerator just prior to loading onto the purge and trap system. High level soil samples must be shaken for 1 – 2 minutes to extract the volatile components into the methanol. Let sample settle prior to taking methanol aliquot. Low level soil sample should be shaken briefly to ensure that the stir bar is loose, and will spin on the Archon or Centurion unit.

10.3.1.1 Low level soil samples: (Archon or Centurion)

Take the low level VOA vial and place directly into the rack of the Archon sampling unit. Surrogate and internal standards are added automatically by the Archon prior to sample purging.

10.3.1.2 Aqueous samples: (Solatek or Centurion)

Load the VOA vial directly on the sampling rack. Dilutions may be prepared volumetrically and poured into VOA vials ensuring there is no headspace left in the vial. The autosampler will then sample 10mL from the VOA vial.

10.3.1.3 High level soil samples: (Archon/Solatek/Centurion)

Shake for 2 minutes, ensuring the methanol has completely penetrated the soil in the vial.

10.3.1.3.1 Through liquid path

Load a maximum of 430µL or appropriate dilution of the methanol into a half-full VOA vial. Fill the VOA vial up to the top with water and cap with no headspace. Allow the autosampler to sample 10mL out of the VOA vial which would be equivalent to injecting 100µL of the methanol extract. Prepare dilutions accordingly.

10.3.1.3.2 Through soil path

Into a VOA vial with a stir bar added, load 4.9mL of water plus a maximum of 100 µL of methanol or appropriate dilution of methanol extract from a 5mL luerlock syringe. Cap the vial and load onto the autosampler.

10.3.2 Qualitative Analysis:

10.3.2.1 The qualitative identification of each compound is based on retention time and on comparison of the sample mass spectrum with the reference mass spectrum. The reference mass spectrum must be generated by the laboratory on the same GC/MS system. The characteristic ions from the reference mass spectrum are defined to be the three ions of greatest relative intensity, or any ions over 30% relative intensity if less than three such ions occur in the reference spectrum. Compounds are identified as present when the following criteria are met:

- 10.3.2.1.1** The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. The Target data system is configured to make this check.
- 10.3.2.1.2** The relative retention time (RRT) of the sample component is within ± 0.06 RRT units of the RRT of the standard component.
- 10.3.2.1.3** The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum. (Example: For an ion with an abundance of 50% in the reference spectrum, the corresponding abundance in a sample spectrum can range between 20% and 80%.)
- 10.3.2.1.4** Structural isomers that produce very similar mass spectra should be identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs (i.e., m and p-xylene).
- 10.3.2.1.5** Identification is hampered when sample components are not resolved chromatographically and produce mass spectra containing ions contributed by more than one analyte. When gas chromatographic peaks obviously represent more than one sample component (i.e., a broadened peak with shoulder(s) or a valley between two or more maxima), appropriate selection of analyte spectra and background spectra is important.
- 10.3.2.1.6** Examination of extracted ion current profiles of appropriate ions can aid in the selection of spectra, and in qualitative identification of compounds. When analytes coelute (i.e., only one chromatographic peak is apparent), the identification criteria may be met, but each analyte spectrum will contain extraneous ions contributed by the coeluting compound.
- 10.3.2.2** For samples containing non-target analytes, a library search will be performed at client request. Compound identification will be classified as "tentative", and the concentration will be reported as an estimate as no quantitative standards are run for these compounds.
- 1) - Relative intensities of major ions in the reference spectrum (ions greater than 10% of the most abundant ion) should be present in the sample spectrum.
 - 2) - The relative intensities of the major ions should agree within $\pm 20\%$. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%.)
 - 3) - Molecular ions present in the reference spectrum should be present in the sample spectrum.
 - 4) - Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.

- 5) - Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks.

10.3.3 Quantitative Analysis:

10.3.3.1 Quantitation of a target compound detected in a sample is performed automatically by the Target data processing software, using the formulae found in Alpha's Quality Manual. Either the average response factor or calibration curve will be used for sample quantitation, depending on how the particular analyte was processed in the initial calibration curve.

If non-target compounds are to be reported, the quantitation is performed automatically by the Target software using the total area of the compound and the nearest internal standard, and assuming a relative response factor of 1.0.

10.4 Continuing Calibration

Calibration verification consists of three steps that are performed at the beginning of each 12-hour analytical shift.

10.4.1 Prior to the analysis of samples or calibration standards, inject or purge 2 μ L (50 ng) of the 4-bromofluorobenzene standard (Section 8.4.4) into the GC/MS system. The resultant mass spectra for the BFB must meet the criteria given in Table 3 before sample analysis begins.

10.4.2 The initial calibration curve for each compound of interest must be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing the continuing calibration check standard (Section 8.5.2). The results from the calibration standard analysis must meet the verification acceptance criteria provided in Sections 10.4.4 through 10.4.7.

10.4.3 A method blank must be analyzed prior to any samples, typically immediately following the continuing calibration check standard, to ensure that the analytical system is free of contaminants. The method blank must not contain any target analytes at or above the required compound reporting limits.

10.4.4 System Performance Check Compounds (SPCCs):

10.4.4.1 The relative response factors for the 5 SPCC compounds must meet the minimum response factor criteria listed in Section 10.2.3.1.

10.4.4.2 If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. Possible problems include standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system.

10.4.5 Calibration Check Compounds (CCCs):

10.4.5.1 The percent difference or drift for each CCC listed in Section 10.2.3.2 must be less than or equal to 20%. If the criterion is not met for any one CCC, (i.e.,

greater than 20% difference or drift), then corrective action must be taken prior to the analysis of samples. All other analytes should also meet the 25%D criteria. An allowance is made to fail 10% of the compounds with > 25% D. If any samples have a hit of an analyte with >25% D, these results should be considered and estimate or rerun to verify.

- 10.4.5.2** Analytical system problems similar to those that affect the SPCC response can also cause problems with the CCCs. If the problem cannot be corrected by performing system maintenance, a new initial calibration must be generated.

10.4.6 Internal Standard Retention Time:

The retention times of the internal standards in the calibration verification standard are evaluated after data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard level of the most recent initial calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.4.7 Internal Standard Response:

If the area for any of the internal standards in the calibration verification standard changes by a factor of two (-50% to +100%) from that in the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.5 Preventive Maintenance

Routine preventive maintenance should be performed on the analytical system. This includes replacement of GC septa and periodic rinsing or replacement of purge and trap tubes and sparge needles. The trap should be replaced every six months, or sooner if performance criteria cannot be met. Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed.

If system performance deteriorates, additional maintenance may be required. This includes replacement of injector ports and seals, clipping several inches off of the front end of the GC column, or in extreme cases the replacement of the GC column. Flushing or replacement of purge and trap lines may be necessary if they become contaminated or develop active sites.

Perform routine preventative maintenance as described throughout this SOP. Record all maintenance in the instrument logbook.

11. Data Evaluation, Calculations and Reporting

11.1.1 LIMS Data Corrections

Please note that the Laboratory Information Management System (LIMS) automatically adjusts soil sample results to account for the % Total Solids of the sample (as determined per Alpha SOP/07-38) and the methanol preservation dilution effect.

11.1.2 Data Calculations

11.1.2.1 Results of Aqueous Sample Analysis:

$$\text{concentration (ug/L)} = \frac{(\text{Conc.}) (\text{Vp}) (\text{DF})}{(\text{Vs})}$$

where:

Conc. = On-column concentration obtained from the quantitation report.
Vp = Volume purged, 10 mL is standard
Vs = Volume of sample purged
DF = Dilution factor, for manually prepared dilutions, not instrumental "dilutions".

11.1.2.2 Results of Sediment/Soil, Sludge, and Waste Analysis:

All solids including soils, sediments, and sludges must be reported on a dry-weight basis.

11.1.2.2.1 Low-Level Samples:

$$\text{concentration (ug/Kg)} = \frac{(\text{Conc.}) (\text{Vp}) (\text{DF})}{(\text{W}) (\%S)}$$

11.1.2.2.2 High-Level Samples:

$$\text{concentration (ug/Kg)} = \frac{(\text{Conc.}) (\text{Vp}) (5000) (\text{DF})}{(\text{W}) (\text{Ve}) (\%S)}$$

where:

Conc. = On-column concentration obtained from the quantitation report.
DF = Dilution factor, for manually prepared dilutions, not instrumental "dilutions".
Ve = Extract volume, mL
Vp = Volume purged, 5 mL is standard
W = Aliquot of sample (wet), g
%S = Sample % solid
5000 = Constant representing the final volume of the methanol extraction.

11.1.2.2.3 High-Level Samples Corrected for Total Water/Solvent Mixture (V_t):

Samples that are extracted prior to analysis in a water miscible solvent such as methanol are diluted by the total volume of the water/solvent mixture. The total mixture volume can only be calculated based on the sample moisture present as determined by the % moisture calculation.

$$\% \text{ moisture} = \frac{g \text{ of sample} - g \text{ of dry sample}}{g \text{ of sample}} \times 100$$

$$V_t = \frac{[mL \text{ of solvent} + (\% \text{ moisture} \times g \text{ of sample})]}{100} \times 1000 mL/mL$$

The calculated V_t value is now added to the volume of methanol in the sample (typically 5000mL), and the corrected concentration is calculated using the equation below:

$$\text{Corrected concentration (mg/Kg)} = \frac{(\text{Conc.}) (V_t + \text{methanol vol.}) (V_p) (DF)}{(W) (V_e) (\%S)}$$

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

All batch and sample specific QC criteria outlined in section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP/08-05. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/08-12 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan -
SOP/08-05 MDL/LOD/LOQ Generation -
SOP/08-12 IDC/DOC Generation -
SOP/14-01 Waste Management and Disposal SOP -

16. Attachments

TABLE 1: 8260 REPORTING LIMITS
TABLE 2: 8260 QC ACCEPTANCE CRITERIA
TABLE 3: BFB TUNING CRITERIA
TABLE 4: STANDARD SOLUTIONS
TABLE 5: 8260B Volatile Internal Standards with Corresponding Target Compounds and Surrogates Assigned for Quantitation -
TABLE 6: 8260B Quantitation Ions -

Table 1
Standard Reported Detection Limits
US EPA METHOD 8260B and 5035/8260B

Analyte	RDL (µg/L)	RDL(µg/KG) ⁽¹⁾	RDL (µg/KG) ⁽²⁾
Acetone ^(3,4,5)	5.0	10.0	250
Acrylonitrile ^(3,4)	5.0	5.0	200
Benzene ^(3,4,5)	0.5	1.0	50
Bromobenzene ^(3,4)	2.5	5.0	250
Bromochloromethane ^(3,4,5)	2.5	5.0	250
Bromodichloromethane ^(3,4,5)	0.5	1.0	50
Bromoform ^(3,4,5)	2.0	4.0	200
Bromomethane ^(3,4,5)	1.0	2.0	100
2-Butanone ^(3,4,5)	5.0	10.0	500
n-Butyl benzene ^(3,4)	0.5	1.0	50
sec-Butyl benzene ^(3,4)	0.5	1.0	50
tert-Butyl benzene ^(3,4)	2.5	5.0	250
Carbon disulfide ^(3,4,5)	5.0	10.0	500
Carbon tetrachloride ^(3,4,5)	0.5	1.0	50
Chlorobenzene ^(3,4,5)	0.5	1.0	50
Chloroethane ^(3,4,5)	1.0	2.0	100
Chloroform ^(3,4,5)	0.75	1.5	75
Chloromethane ^(3,4,5)	2.5	5.0	250
o-Chlorotoluene ^(3,4)	2.5	5.0	250
Cyclohexane ⁽⁵⁾	10	20	1000
p-Chlorotoluene ^(3,4)	2.5	5.0	250
Dibromochloromethane ^(3,4,5)	0.5	1.0	50
1,2-Dibromo-3-chloropropane ^(3,4,5)	2.5	5.0	250
1,2-Dibromoethane ^(3,4,5)	2.0	5.0	250
Dibromomethane ^(3,4)	5.0	10.0	500
1,2-Dichlorobenzene ^(3,4,5)	2.5	5.0	250
1,3-Dichlorobenzene ^(3,4,5)	2.5	5.0	250
1,4-Dichlorobenzene ^(3,4,5)	2.5	5.0	250
1,4-Dichlorobutane ^(3,4)	5.0	10.0	500
trans-1,4-Dichloro-2-butene ^(3,4)	2.5	5.0	250
Dichlorodifluoromethane ^(3,4,5)	5.0	10.0	500
1,1-Dichloroethane ^(3,4,5)	0.75	1.5	75
1,2-Dichloroethane ^(3,4,5)	0.5	1.0	50
1,1-Dichloroethene ^(3,4,5)	0.5	1.0	50
cis-1,2-Dichloroethene ^(3,4,5)	0.5	1.0	50
trans-1,2-Dichloroethene ^(3,4,5)	0.75	1.5	75

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Table 1 (continued)
Standard Reported Detection Limits
US EPA METHOD 8260B and 5035/8260B

Analyte	RDL (µg/L)	RDL (µg/KG) ⁽¹⁾	RDL (µg/KG) ⁽²⁾
1,2-Dichloropropane ^(3,4,5)	1.75	3.5	175
1,3-Dichloropropane ^(3,4)	2.5	5.0	250
2,2-Dichloropropane ^(3,4)	2.5	5.0	250
1,1-Dichloropropene ^(3,4)	2.5	2.5	250
cis-1,3-Dichloropropene ^(3,4,5)	0.5	1.0	50
p-Diethylbenzene ⁽⁴⁾	2.0	4.0	200
Diisopropyl Ether ⁽⁶⁾	2.0	4.0	200
1,4-Dioxane ⁽⁵⁾	250	100	5000
trans-1,3-Dichloropropene ^(3,4,5)	0.5	1.0	50
Ethylbenzene ^(3,4,5)	0.5	1.0	50
Ethyl ether ^(3,4)	2.5	5.0	250
4-Ethyltoluene ⁽⁴⁾	2.0	4.0	200
Ethyl methacrylate ^(3,4)	5.0	10.0	500
Ethyl-Tert-Butyl-Ether ⁽⁶⁾	2.0	4.0	200
Freon-113 ⁽⁵⁾	10.0	20	1000
Hexachlorobutadiene ^(3,4)	0.5	5.0	250
2-Hexanone ^(3,4,5)	5.0	10.0	500
Isopropylbenzene ^(3,4,5)	0.5	1.0	50
p-Isopropyltoluene ^(3,4)	0.5	1.0	50
Methyl Acetate ⁽⁵⁾	20	20	1000
Methylene chloride ^(3,4,5)	3.0	10.0	500
Methyl Cyclohexane ⁽⁵⁾	20	4.0	200
4-Methyl-2-pentanone ^(3,4,5)	5.0	10.0	500
Methyl-tert-butyl-ether ^(3,4,5)	1.0	2.0	100
Naphthalene ^(3,4)	2.5	5.0	250
n-Propylbenzene ^(3,4)	0.5	1.0	50
Styrene ^(3,4,5)	1.0	2.0	100
Tert-Butyl Alcohol ⁽⁵⁾	30	100	5000
Tertiary-Amyl Methyl Ether ⁽⁶⁾	2.0	4.0	200
1,1,1,2-Tetrachloroethane ^(3,4)	0.5	1.0	50
1,2,4,5-Tetramethylbenzene ⁽⁴⁾	2.0	4.0	200
1,1,2,2-Tetrachloroethane ^(3,4,5)	0.5	1.0	50
Tetrachloroethene ^(3,4,5)	0.5	1.0	50
Tetrahydrofuran ⁽³⁾	10.0	20.0	1000
Toluene ^(3,4,5)	0.75	1.5	75
1,2,3-Trichlorobenzene ^(3,4,5)	2.5	5.0	250
1,2,4-Trichlorobenzene ^(3,4,5)	2.5	5.0	250
1,3,5-Trichlorobenzene ⁽⁶⁾	2.0	5.0	250
1,1,1-Trichloroethane ^(3,4,5)	0.5	1.0	50

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1,1,2-Trichloroethane ^(3,4,5)	0.75	1.5	75
Trichloroethene ^(3,4,5)	0.5	1.0	50
Trichlorofluoromethane ^(3,4,5)	2.5	5.0	250
1,2,3-Trichloropropane ^(3,4)	5.0	10.0	500
1,2,4-Trimethylbenzene ^(3,4)	2.5	5.0	250
1,3,5-Trimethylbenzene ^(3,4)	2.5	5.0	250
Vinyl acetate ^(3,4)	5.0	10.0	500
Vinyl chloride ^(3,4,5)	1.0	2.0	100
m/p-Xylenes ^(3,4,5)	1.0	2.0	100
o-Xylene ^(3,4,5)	1.0	2.0	100

- (1) Detection Limits are for Low-level Aqueous preserved samples.
- (2) Detection Limits are for High-level Methanol preserved samples.
- (3) Analyte reported by standard 8260 reporting list.
- (4) Analyte reported by New York TCL reporting list.
- (5) Analyte reported by New Jersey TCL reporting list.
- (6) Analyte reported for New Hampshire in addition to standard 8260 reporting list.
 - Note; Reporting Limits are based on standard 8260 reporting list, RL's may vary for New York and New Jersey reporting lists.

Table 2

QUALITY CONTROL ACCEPTANCE CRITERIA

Surrogate Spike Percent Recovery	Aqueous Limits		Soil Limits	
	Lower Control Limit	Upper Control Limit	Lower Control Limit	Upper Control Limit
1,2-Dichloroethane-d ₄	70%	130%	70%	130%
4-Bromofluorobenzene	70%	130%	70%	130%
Toluene-d ₈	70%	130%	70%	130%
Dibromofluoromethane	70%	130%	70%	130%

Table 3
BFB (4-BROMOFLUOROBENZENE) MASS INTENSITY CRITERIA

m/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	Greater than 50% of m/z 95
175	5 to 9% of m/z 174
176	Greater than 95% but less than 101% of m/z 174
177	5 to 9% of m/z 176

Table 4

Stock Standard Concentrations and Calibration Concentration Levels

Target Compound	Stock (µg/mL)	Level 1 (µg/L)	Level 2 (µg/L)	Level 3 (µg/L)	Level 4 (µg/L)	Level 5 (µg/L)	Level 6 (µg/L)	Level 7 (µg/L)	Level 8 (µg/L)
Acetone	2000	0.5	2	10	20	30	50	100	200
Acrylonitrile	2000	0.5	2	10	20	30	50	100	200
Benzene	2000	0.5	2	10	20	30	50	100	200
Bromobenzene	2000	0.5	2	10	20	30	50	100	200
Bromochloromethane	2000	0.5	2	10	20	30	50	100	200
Bromodichloromethane	2000	0.5	2	10	20	30	50	100	200
Bromoform	2000	0.5	2	10	20	30	50	100	200
Bromomethane	2000	0.5	2	10	20	30	50	100	200
2-Butanone	2000	0.5	2	10	20	30	50	100	200
n-Butyl benzene	2000	0.5	2	10	20	30	50	100	200
sec-Butyl benzene	2000	0.5	2	10	20	30	50	100	200
tert-Butyl benzene	2000	0.5	2	10	20	30	50	100	200
Carbon disulfide	2000	0.5	2	10	20	30	50	100	200
Carbon tetrachloride	2000	0.5	2	10	20	30	50	100	200
Chlorobenzene	2000	0.5	2	10	20	30	50	100	200
Chloroethane	2000	0.5	2	10	20	30	50	100	200
2-Chloroethylvinyl Ether	2000	0.5	2	10	20	30	50	100	200
Chloroform	2000	0.5	2	10	20	30	50	100	200
Chloromethane	2000	0.5	2	10	20	30	50	100	200
o-Chlorotoluene	2000	0.5	2	10	20	30	50	100	200
p-Chlorotoluene	2000	0.5	2	10	20	30	50	100	200
Cyclohexane	2000	0.5	2	10	20	30	50	100	200
Dibromochloromethane	2000	0.5	2	10	20	30	50	100	200
1,2-Dibromo-3-chloropropane	2000	0.5	2	10	20	30	50	100	200
1,2-Dibromoethane	2000	0.5	2	10	20	30	50	100	200
Dibromomethane	2000	0.5	2	10	20	30	50	100	200
1,2-Dichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,3-Dichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,4-Dichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,4-Dichlorobutane	2000	0.5	2	10	20	30	50	100	200
trans-1,4-Dichloro-2-butene	2000	0.5	2	10	20	30	50	100	200
Dichlorodifluoromethane	2000	0.5	2	10	20	30	50	100	200
1,1-Dichloroethane	2000	0.5	2	10	20	30	50	100	200
1,2-Dichloroethane	2000	0.5	2	10	20	30	50	100	200
1,1-Dichloroethene	2000	0.5	2	10	20	30	50	100	200
cis-1,2-Dichloroethene	2000	0.5	2	10	20	30	50	100	200
trans-1,2-Dichloroethene	2000	0.5	2	10	20	30	50	100	200
1,2-Dichloropropane	2000	0.5	2	10	20	30	50	100	200
1,3-Dichloropropane	2000	0.5	2	10	20	30	50	100	200

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2,2-Dichloropropane	2000	0.5	2	10	20	30	50	100	200
1,1-Dichloropropene	2000	0.5	2	10	20	30	50	100	200
cis-1,3-Dichloropropene	2000	0.5	2	10	20	30	50	100	200
trans-1,3-Dichloropropene	2000	0.5	2	10	20	30	50	100	200
p-Diethylbenzene	2000	0.5	2	10	20	30	50	100	200
Diisopropyl Ether	2000	0.5	2	10	20	30	50	100	200
1,4-Dioxane	10000	100	400	1000	2000	3000	4000	5000	6000
Ethyl Acetate	2000	0.5	2	10	20	30	50	100	200
Ethylbenzene	2000	0.5	2	10	20	30	50	100	200
Ethyl ether	2000	0.5	2	10	20	30	50	100	200
Ethyl methacrylate	2000	0.5	2	10	20	30	50	100	200
Ethyl Tert-Butyl Ether	2000	0.5	2	10	20	30	50	100	200
4-Ethyltoluene	2000	0.5	2	10	20	30	50	100	200
Freon-113	2000	0.5	2	10	20	30	50	100	200
Halothane	2000	0.5	2	10	20	30	50	100	200
Hexachlorobutadiene	2000	0.5	2	10	20	30	50	100	200
2-Hexanone	2000	0.5	2	10	20	30	50	100	200
Isopropylbenzene	2000	0.5	2	10	20	30	50	100	200
p-Isopropyltoluene	2000	0.5	2	10	20	30	50	100	200
Methyl Acetate	2000	0.5	2	10	20	30	50	100	200
Methylene Chloride	2000	0.5	2	10	20	30	50	100	200
Methyl Cyclohexane	2000	0.5	2	10	20	30	50	100	200
4-Methyl-2-pentanone	2000	0.5	2	10	20	30	50	100	200
Methyl-tert-butyl-ether	2000	0.5	2	10	20	30	50	100	200
Naphthalene	2000	0.5	2	10	20	30	50	100	200
n-Propylbenzene	2000	0.5	2	10	20	30	50	100	200
Styrene	4000	1	4	20	40	60	100	200	400
Tert-Butyl alcohol	10000	2.5	10	50	100	150	250	500	1000
Tertiary-Amyl Methyl Ether	2000	0.5	2	10	20	30	50	100	200
1,1,1,2-Tetrachloroethane	2000	0.5	2	10	20	30	50	100	200
1,1,2,2-Tetrachloroethane	2000	0.5	2	10	20	30	50	100	200
Tetrachloroethene	2000	0.5	2	10	20	30	50	100	200
Tetrahydrofuran	2000	0.5	2	10	20	30	50	100	200
1,2,4,5-Tetramethylbenzene	2000	0.5	2	10	20	30	50	100	200
Toluene	2000	0.5	2	10	20	30	50	100	200
1,2,3-Trichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,2,4-Trichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,3,5-Trichlorobenzene	2000	0.5	2	10	20	30	50	100	200
1,1,1-Trichloroethane	2000	0.5	2	10	20	30	50	100	200
1,1,2-Trichloroethane	2000	0.5	2	10	20	30	50	100	200
Trichloroethene	2000	0.5	2	10	20	30	50	100	200
Trichlorofluoromethane	2000	0.5	2	10	20	30	50	100	200
1,2,3-Trichloropropane	2000	0.5	2	10	20	30	50	100	200
1,2,4-Trimethylbenzene	2000	0.5	2	10	20	30	50	100	200
1,3,5-Trimethylbenzene	2000	0.5	2	10	20	30	50	100	200
Vinyl acetate	2000	0.5	2	10	20	30	50	100	200

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Vinyl chloride	2000	0.5	2	10	20	30	50	100	200
m/p-Xylenes	4000	1	4	20	40	60	100	200	400
o-Xylene	4000	1	4	20	40	60	100	200	400

Table 4 (continued)

Stock Standard Concentrations and Calibration Concentration Levels

Target Compounds	Stock (µg/mL)	Level 1 (µg/L)	Level 2 (µg/L)	Level 3 (µg/L)	Level 4 (µg/L)	Level 5 (µg/L)	Level 6 (µg/L)	Level 7 (µg/L)	Level 8 (µg/L)
Internal Standards									
Fluorobenzene	2500	10	10	10	10	10	10	10	10
Chlorobenzene-d5	2500	10	10	10	10	10	10	10	10
1,4-Dichlorobenzene-d4	2500	10	10	10	10	10	10	10	10
Surrogates									
Dibromofluoromethane	2500	10	10	10	10	10	10	10	10
1,2-Dichloroethane-d4	2500	10	10	10	10	10	10	10	10
Toluene-d8	2500	10	10	10	10	10	10	10	10
4-Bromofluorobenzene	2500	10	10	10	10	10	10	10	10

- For Low Level Soil analysis, the calibration levels are the same in µg/Kg units.
- For High Level Soil analysis, the calibration levels are at 50X the levels listed due to sample preparation requirements.

TABLE 5

**8260B Volatile Internal Standards
with Corresponding MCP Target Compounds
and Surrogates Assigned for Quantitation**

Fluorobenzene

Chlorobenzene-d5

1,4-Dichlorobenzene-d4

Dichlorodifluoromethane	Toluene-d8 (surr)	Isopropylbenzene
Chloromethane	Toluene	Bromoform
Vinyl Chloride	Ethyl Methacrylate	1,4-dichloro-2-butane
Bromomethane	Trans-1,3-dichloropropene	1,1,2,2,-tetrachloroethane
Chloroethane	1,1,2-trichloroethane	4-bromofluorobenzene (surr)
Trichlorofluoromethane	2-hexanone	1,2,3-trichloropropane
Ethyl Ether	1,3-dichloropropane	trans-1,4-dichloro-2-butene
Freon 113	Tetrachloroethene	n-propylbenzene
Acetone	Chlorodibromomethane	Bromobenzene
1,1,-dichloroethene	1,2-dibromoethane	4-ethyltoluene
Tert-Butyl Alcohol	Chlorobenzene	1,3,5-trimethylbenzene
Methyl Acetate	1,1,1,2-tetrachloroethane	2-chlorotoluene
Carbon Disulfide	Ethylbenzene	4-chlorotoluene
Methylene Chloride	p/m xylene	tert-butylbenzene
Acrylonitrile	o xylene	1,2,4-trimethylbenzene
Methyl Tert Butyl Ether	Styrene	sec-butylbenzene
Halothane		p-isopropyltoluene
Trans-1,2-dichloroethene		1,3-dichlorobenzene
Diisopropyl Ether		1,4-dichlorobenzene
Vinyl Acetate		n-butylbenzene
1,1-dichloroethane		p-diethylbenzene
Ethyl-Tert-Butyl-Ether		1,2-dichlorobenzene
2-butanone		1,2,4,5-tetramethylbenzene
2,2-dichloropropane		1,2-dibromo-3-chloropropane
Cis-1,2-dichloroethene		1,3,5-trichlorobenzene
Chloroform		1,2,4-trichlorobenzene
Bromochloromethane		Hexachlorobutadiene
Tetrahydrofuran		Naphthalene
Dibromofluoromethane (surr)		1,2,3-trichlorobenzene
1,1,1-trichloroethane		
Cyclohexane		
1,1-dichloropropene		
Carbon Tetrachloride		
Tertiary-Amyl Methyl Ether		
1,2-dichloroethane-d4 (surr)		
1,2-dichloroethane		
Benzene		
Trichloroethene		
Methyl Cyclohexane		
1,2-dichloropropane		
Bromodichloromethane		
1,4-Dioxane		
Dibromomethane		
2-Chloroethylvinyl Ether		
4-methyl-2-pentanone		
Cis-1,3-dichloropropene		

TABLE 6
8260B Quantitation Ion

Analyte	Quantitation Ion	Analyte	Quantitation Ion
Dichlorodifluoromethane	85	Ethyl Methacrylate	69
Chloromethane	50	Trans-1,3-dichloropropene	75
Vinyl Chloride	62	1,1,2-trichloroethane	83
Bromomethane	94	2-hexanone	43
Chloroethane	64	1,3-dichloropropane	76

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Trichlorofluoromethane	101	Tetrachloroethene	166
Ethyl Ether	74	Chlorodibromomethane	129
Freon 113	101	1,2-dibromoethane	107
Acetone	43	Chlorobenzene	112
1,1,-dichloroethene	96	1,1,1,2-tetrachloroethane	131
Tert-Butyl Alcohol	59	Ethylbenzene	91
Methyl Acetate	43	p/m xylene	106
Carbon Disulfide	84	o xylene	106
Methylene Chloride	76	Styrene	104
Acrylonitrile	53	Isopropylbenzene	105
Methyl Tert Butyl Ether	73	Bromoform	173
Halothane	117	1,4-dichloro-2-butane	55
Trans-1,2-dichloroethene	96	1,1,2,2,-tetrachloroethane	83
Diisopropyl Ether	45	1,2,3-trichloropropane	75
Vinyl Acetate	43	Trans-1,4-dichloro-2-butene	53
1,1-dichloroethane	63	n-propylbenzene	91
Ethyl-Tert-Butyl-Ether	59	Bromobenzene	156
2-butanone	43	4-ethyltoluene	105
2,2-dichloropropane	77	1,3,5-trimethylbenzene	105
Cis-1,2-dichloroethene	96	2-chlorotoluene	91
Chloroform	83	4-chlorotoluene	91
Bromochloromethane	128	tert-butylbenzene	119
Tetrahydrofuran	42	1,2,4-trimethylbenzene	105
1,1,1-trichloroethane	97	sec-butylbenzene	105
Cyclohexane	56	p-isopropyltoluene	119
1,1-dichloropropene	75	1,3-dichlorobenzene	146
Carbon Tetrachloride	117	1,4-dichlorobenzene	146
Tertiary-Amyl Methyl Ether	73	n-butylbenzene	91
1,2-dichloroethane	62	p-diethylbenzene	119
Benzene	78	1,2-dichlorobenzene	146
Trichloroethene	95	1,2,4,5-tetramethylbenzene	119
Methyl Cyclohexane	83	1,2-dibromo-3-chloropropane	75
1,2-dichloropropane	63	1,3,5-trichlorobenzene	180
Bromodichloromethane	83	1,2,4-trichlorobenzene	180
1,4-dioxane	88	Hexachlorobutadiene	225
Dibromomethane	93	Naphthalene	128
2-Chloroethylvinyl Ether	63	1,2,3-trichlorobenzene	180
4-methyl-2-pentanone	58		
Cis-1,3-dichloropropene	75		
Toluene	92		

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***Standard Operating Procedures for
Soil Sampling for Volatile Organic Compounds***

INTRODUCTION

The purpose of this Standard Operating Procedure is to provide instruction for the collection and preservation of solid materials (e.g., soils, sediments, and sludge) for analysis of the potential presence of volatile organic compounds (VOCs).

EQUIPMENT AND SUPPLIES

- Pre-weighed VOA vial with screw cap and Teflon septum containing appropriate sample preservation solution (methanol or sodium bisulfate – see EPA Method 5035A for further discussion)
- Sample collection device for minimally disturbed delivery of sample, such as:
 - Encore™ sampler
 - Terra Core™ sampler
 - Purge-and-trap soil sampler
 - Disposable plastic syringe with barrel cut-off and smaller than vial opening
- If project specific work plan(s) specify, portable balance and calibration weights (balance should have accuracy to weigh to 0.01 grams)
- Chain of custody records and custody seals
- Sample collection documentation (sample labels, sampling worksheets, logbooks)

PROCEDURE

- A. Using an appropriate sample collection device (see above), collect approximately 5g of sample as soon as possible after the surface of the soil or other material has been exposed to the atmosphere, generally within a few minutes at most. To the extent practical, samples should be obtained from undisturbed portions of the solid material.
- B. Using the sample collection device, add the approximately 5g of sample to the sample vial containing the preservative solution.
- C. Wipe any soil off the vial threads and immediately seal the vial with the septum and screw cap.
- D. If project specific work plan(s) specify, use portable balance to weigh the sealed vial containing the sample (after noting either the laboratory-indicated weight, or determining the tare weight of the vial in the field) to ensure that 5.0 ± 0.5 grams of sample was added.
- E. Label sample and indicate type of preservative solution.
- F. Sign and affix custody seal across cap of vial.
- G. Store sample at 4 °C plus or minus 2°C.
- H. If project specific work plan(s) specify, replicate samples should be collected wherever possible. This enables the laboratory additional sample(s) for re-analysis, if necessary. Replicate samples should be taken as quickly as possible from the same stratum and within the closest proximity to the location of the parent sample possible
- I. A separate aliquot of soil should be collected for screening purposes and moisture content determination if required by the laboratory. This aliquot should NOT contain sample preservation solution.

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REFERENCES:

USEPA Method 5035A Closed System Purge-And-Trap and Extraction for Volatile Organics in Soil and Waste
Samples, Draft Revision 1, July, 2002

Author: Rhonda Kay Date: 7/2/07
Scientist, Engineer or Technician

Reviewed: James R. Bowers Date: 6/30/07
Quality Assurance Unit

Approved: CM Cline Date: 7/6/07
Officer

***Standard Operating Procedure
for
Calibration and Operation of the MiniRAE 3000
Portable Handheld VOC Photo-Ionization Detector***

INTRODUCTION

Photo-ionization detectors are instruments commonly used to check for presence of volatile organic vapors in air. Measurements are used for Health and Safety as well as investigative purposes. This Standard Operating Procedure addresses use and operation of the MiniRAE 3000 photo-ionization detector. All photo-ionization detectors (PIDs) operate on the same basic principle. A fan or pump pulls air into a chamber that is bathed in ultra-violet light. This light excites the electrons of the outer shell of the atoms of the organic molecule. The energy required to remove the outermost electrons from the molecule is called the ionization potential (IP) and is specific for any compound or atomic species (Cartier, 1989). These ions pass through a detector that measures the energy level of the gas. The more organic molecules present, the more ions, and the more energy detected. The reading is displayed on an analog meter in units of parts per million by volume of calibration gas.

These units have individual limitations of the linear detection range and for field conditions over which they will operate. The ability to detect a chemical depends on the ability to ionize it. Therefore the IP of a chemical to be detected must be compared to the energy generated by the ultra-violet (UV) lamp of the instrument. PIDs will typically detect compounds with IPs lower than the energy of the PID lamp. The energy of lamps available are 9.8, 10.6, and 11.7 eV (electron volts).

EQUIPMENT AND SUPPLIES

MiniRAE 3000 equipped with appropriate gas discharge lamp
100 ppm Isobutylene span gas canister with a flow500 cc/min flow-limiting regulator OR a >500 cc/min regulator and a T-connection that allows excess flow to escape OR a Tedlar bag
Instrument logbook
Field calibration forms
External filter

PROCEDURE**A. General Considerations**

Weather: The MiniRAE 3000 has limited function capabilities in damp and extreme cold conditions. Detector specifications include a temperature range of -4° F to 113° F and a humidity range from 0% to 95%. In atmospheres outside of these ranges, the instrument may produce erroneous readings. Care should be taken to avoid exposure to damp atmospheres, if possible. In damp conditions the moisture trap should be inserted onto the probe tip to prevent moisture from entering the unit. Operation of the MiniRAE 3000 with the moisture trap will require longer retention times to elapse before making a reading. The extra time required will depend upon a number of variables and cannot be quantified.

Extreme cold can cause the fan not to operate. Keep the MiniRAE 3000 in a dry, warm, secure station whenever the instrument is not in use.

Personnel Safety: The MiniRAE 3000 is Intrinsically Safe for use in Class I, Division I Groups A, B, C, D (i.e., environments where the following types of explosive gases, vapors, and liquids are present at all times: acetylene, hydrogen, ether, and hydrocarbons/fuels/solvents). **DO NOT CHARGE THE INSTRUMENT OR CHANGE THE BATTERY IN EXPLOSIVE ENVIRONMENTS.** The MiniRAE 3000 will not indicate low oxygen atmospheres or the presence of explosive gases that cannot be ionized and is not to be used in place of a Multi-gas Indicator (SOP-JCO-031).

B. MiniRAE 3000 Photo-Ionization Detector Operation, Maintenance, and Calibration

The operation, maintenance and calibration of the MiniRAE 3000 instrument is discussed in detail in the instruction manual, which is kept with the instrument. This manual shall be read and reviewed prior to operating the instrument. The general guidelines for the use of the instrument are discussed below.

B.1. Instrument Check

1. The operational status of the MiniRAE 3000 should be checked while in the office. The RAE systems logo should appear after pressing and holding the [MODE] key. Once start-up and self-test procedures are complete, the instrument will show a numerical reading with icons on the display screen. A calibration icon will display if calibration is required either due to a lamp change, sensor replacement, change of calibration gas type, or if more than 30 days have elapsed since the last calibration.
2. Press the flashlight key to ensure that the built-in flashlight turns on.
3. Hold a xylene-containing marker, such as a Sharpie®, in front of the detection probe. The instrument is operational if there is a visible sensor reading.
4. The MiniRAE 3000 may have residual contamination from previous use. Once the Sharpie® marker is drawn away from the detection probe, check the MiniRAE 3000 screen. The screen should return to "0.00 ppm" or a reasonable background concentration (0.00 ppm to 1.5 ppm) without fluctuations. If the display fluctuates between "0.00 ppm" and reading larger than a typical background level, report the condition to the Senior Environmental Technician.
5. Calibration may not be necessary if a calibration check sequence proves accurate to a span gas. With the MiniRAE 3000 on, connect the instrument to the span gas cylinder or a Tedlar bag filled with span gas. If the response is +/- 2%, calibration may not be needed. Record this procedure and results in your field book along with the background reading. If calibration is required, follow the steps provided in B.2, below.
6. Press and hold the [MODE] key for five seconds to turn the lamp and pump off.

B.2. Standard Two-Point Calibration Procedure - To occur at "background location" on subject site (e.g., upwind, in a dry area, away from equipment operating at the site).

A two-point calibration uses a zero (“fresh” air) air and a span gas of known concentration. “Fresh” air is clean, dry air without organic impurities and an oxygen value of 20.9 percent. The zero calibration can be bypassed by selecting “Span Calib” in the calibration menu. The default span gas is 100 ppm isobutylene (isobutene).

1. Press and hold the [MODE] and the [N/-] buttons until the Password screen appears (no password is required). Press [Mode] to enter calibration.
2. Press [Y/+] to begin zero (fresh air) calibration, selecting the highlighted “Zero Calib”.
3. Press [Y/+] to start the calibration process; the message “Please apply zero gas” is displayed.
4. Connect the instrument to a “fresh” air source such as a zero gas cylinder or Tedlar bag, or place the instrument in background locations at the Site.
5. Turn on the zero calibration gas if necessary, press [Y/+] to start calibration.
6. Zero calibration occurs over a 30-second period; the message “Zeroing...” is displayed until zero calibration is complete. The message “Zeroing is done! Reading = 0.0 ppm” will then be displayed.
7. The screen will return to the calibration menu; press [Y/+] to enter Span Calibration. The name of the default span gas, “Isobutene Span = 100 ppm”, will appear.
8. Connect the instrument to a cylinder of the span gas with a 500 cc/min flow-limiting regulator, to a Tedlar bag filled with the gas, or to a >500 cc/min regulator attached to tubing with a T-connection that will allow excess gas to escape.
9. Press [Y/+] to initiate span gas calibration. Calibration occurs over a 30-second period; the message “Calibrating...” will be displayed until span gas calibration is complete. The message “Span 1 is done! Reading = ###.# ppm” will then be displayed where the displayed number “###.#” should be 100.0 ppm or very close to this value.
10. Record this value in both the instrument log book and on the field calibration forms.
11. Press [MODE]; the message “Updating settings...” is displayed until the screen returns to the main display and begins or resumes monitoring.

See the MiniRAE 3000 User’s Guide for instructions to conduct a three-point calibration.

B.3. Operation

1. Consult the site specific Health and Safety Plan (HASP), become familiar with its stipulations, particularly the permissible exposure limits, before performing any field work.
2. **ALARM SETTING.** Set the alarm (a loud buzzer and/or red flashing LED) to the action level appropriate for upgrading personal protective equipment as stated in the HASP. This is accomplished by the following:
 - a. Press the [MODE] and [N/-] keys.
 - b. Press [N/-] twice to cycle to the Alarm Setting menu; press [Y/+] to select Alarm Settings. The alarm settings are comprised of High Alarm, Low Alarm, STEL Alarm, TWA Alarm, Alarm Type, and Buzzer & Light.
 - c. Press the [N/-] to scroll through the Alarm Limit menu until the display shows the limit to be changed.

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- d. Press [Y/+] to select the alarm type to be changed.
 - e. Press [Y/+] to increase each digit's value; press [N/-] to scroll to the next digit.
 - f. Press [MODE] when all digits are entered.
 - g. Press [Y/+] to save the changes, or press [N/-] to undo the changes are return to the previous settings.
 - h. When alarm types have been changed or bypassed, press [MODE] to return to the Programming Menu.
 3. **MAXIMUM CONCENTRATION.** Peak readings are recorded when the instrument is running in Hygiene Mode (the default mode that provides basic functionality). This reading is displayed by pressing [N/-] from the main screen displaying current detections. Continuing to press [N/-] will allow the user to scroll through the other instrument settings and data (such as the date, time, temperature, span gas settings and lamp settings) before returning to the main screen.
 4. **BATTERY INDICATOR.** When the instrument's battery is fully charged, a battery icon shows a full battery and does not flash. A fully charged battery will run the instrument for 16 hours. When the battery is low, the battery icon will blink and the instrument will beep once and flash every minute to indicate that the machine should be turned off within 10 minutes. To charge, turn the instrument off by holding the [MODE] button for 5 seconds. Reconnect the instrument to its cradle and connect the cradle to a wall electrical outlet via an AC/DC adapter. The instrument will lock in place and the LED in the cradle will glow. The charging time is less than 8 hours for a fully discharged battery.
 5. **FIELD WORK.**
 - a. Enter the work area from the "background location", frequently viewing the display to monitor breathing space readings.
 - b. Conduct the tasks required according to the appropriate protocols (in accord with approved Health and Safety and/or work plans) frequently observing breathing zone readings and recording them in the job specific field book, along with the time and location of the reading.
 - c. In the event of erratic operations of the PID, periodically confirm that the instrument is holding its calibration by connecting the span gas canister or filled Tedlar bag to the MiniRAE 3000 as described in Section B.2 and note the concentration reading. Note this calibration confirmation in the instrument log book and in the job specific field book.

C. Records

1. Records shall be kept of the use and calibration of the instrument and maintained in a permanent file.
2. Any anomalies or equipment damages should be immediately reported, via written report memorandum, to the Senior Environmental Technician.

D. Decontamination

1. Wipe the outside of the instrument case, display, straps and cables that are attached to the instrument with a clean, soft, dry cloth.

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2. TAKE CARE TO KEEP WATER FROM ENTERING THE TIP ASSEMBLY OF THE INSTRUMENT.

REFERENCES

Cartier and Associates, 1989, General Safety and Health Provisions, OSHA 1910.120, Accompanying loose-leaf course text, pp IX-14.

Rae Systems, 2007, MiniRAE 3000 User's Guide, Revision A, accessed at http://www.raesystems.com/~raedocs/manuals/MiniRAE3000_manual_v4.pdf. November 2007.

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Standard Operating Procedures for Collecting Vapor Samples in Tedlar® Bags using a Vacuum Box

INTRODUCTION

The purpose of this Standard Operating Procedure is to provide instruction for the use of Tedlar® bags and vacuum boxes in collecting vapor samples for screening with a field instrument such as a photoionization detector (PID).

EQUIPMENT AND SUPPLIES

Vacuum pump (e.g., SKC 224-XR)
Vacuum box (e.g., SKC Vac-U-Chamber)
Teflon® tubing
Tedlar® sampling bags (1 L)
Sample collection documentation (e.g., air sampling forms, logbooks)
Photoionization Detector or other field instrument

Note: Sampling bags constructed of different materials, such as polyvinylidene fluoride (PVDF), may be substituted for Tedlar® bags as long as the substitute bag has been documented as suitable for collecting samples of vapor containing volatile organic compounds (VOCs).

PROCEDURE

- A. Obtain a new, unused Tedlar® bag. Tedlar® bags should be stored and transported separately from potential sources of contamination in order to minimize the risk of false positive readings.
- B. Place the Tedlar® bag in the vacuum box and connect the inlet stem of the Tedlar® bag to the sample inlet port inside the vacuum box using silicone tubing (see Figure 3 in Attachment A).
- C. Connect a vacuum pump to the sample inlet port on the exterior of the vacuum box using a new piece of silicone tubing fitting. Open the valve on the Tedlar® bag inlet stem by turning the knob a single revolution counterclockwise.
- D. Operate the pump to purge air from the Tedlar® bag. Once the bag is empty, close the inlet valve on the Tedlar® bag by turning the knob clockwise until snug. Disconnect the vacuum pump from the sample inlet port.
- E. Connect the sample inlet port on the exterior of the vacuum box to the sample port on the source air stream, using a new piece of clean and unused Teflon® tubing to minimize potential VOC adsorption on tubing walls. Open the valve on the source air stream sample port.
- F. Connect the vacuum pump to the purge port on the exterior of the vacuum box using the quick-connect fitting (see Figure 5 in Attachment A). Operate the vacuum pump to draw vapor through the sample tubing, purging the tubing of ambient air:
 - If the air flow rate through the vacuum pump is **known**, estimate the tubing volume and operate the pump until three tubing volumes have been purged. The volume of ¼" inner diameter tubing is approximately 10 mL/foot.

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- If the air flow rate through the vacuum pump is **unknown**, connect a new or used Tedlar® bag to the vacuum pump outlet using a piece of silicone tubing. Operate the vacuum pump until the bag is filled, then disconnect the bag. Do not use this bag for sample collection.
- G. Once purging is complete, close the valve at the source air stream sample port, turn off the vacuum pump, and disconnect the pump from the vacuum box.
- H. To fill a Tedlar® bag with a vapor sample, connect the vacuum pump to the vacuum port on the vacuum box. Open the inlet valve on the Tedlar® bag. Close and seal the vacuum box. Turn on the vacuum pump. The vacuum pump will create a vacuum inside the vacuum box, inducing vapor to flow from the sample port to the Tedlar® bag. Monitor the Tedlar® bag through the window in the vacuum box.
- I. Operate the vacuum pump until the Tedlar® bag is approximately 80% full based on visual inspection (see Figure 2 in Attachment A). Turn off the vacuum pump, open the vacuum box, and close the inlet valve on the Tedlar® bag.
- J. Record the sample location, date, and time of sample collection on the appropriate field form or field logbook.
- K. Perform the target instrument readings following the SOPs established for the specific field instrument used (e.g., JCO-SOP-044 for calibration and operation of a photoionization detector).

ATTACHMENTS

Attachment A SKC Ltd., Application Guide for Using Sample Bags with the Vac-U-Chamber. SKC Publication 1302 Rev 0312

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Attachment A

SKC Application Guide for the Vac-U-Chamber

Standard Operating Procedures for Collecting Vapor Samples in Tedlar® Bags using a Vacuum Box

INTRODUCTION

The purpose of this Standard Operating Procedure is to provide instruction for the use of Tedlar® bags and vacuum boxes in collecting vapor samples for screening with a field instrument such as a photoionization detector (PID).

EQUIPMENT AND SUPPLIES

Vacuum pump (e.g., SKC 224-XR)
Vacuum box (e.g., SKC Vac-U-Chamber)
Teflon® tubing
Tedlar® sampling bags (1 L)
Sample collection documentation (e.g., air sampling forms, logbooks)
Photoionization Detector or other field instrument

Note: Sampling bags constructed of different materials, such as polyvinylidene fluoride (PVDF), may be substituted for Tedlar® bags as long as the substitute bag has been documented as suitable for collecting samples of vapor containing volatile organic compounds (VOCs).

PROCEDURE

- A. Obtain a new, unused Tedlar® bag. Tedlar® bags should be stored and transported separately from potential sources of contamination in order to minimize the risk of false positive readings.
- B. Place the Tedlar® bag in the vacuum box and connect the inlet stem of the Tedlar® bag to the sample inlet port inside the vacuum box using silicone tubing (see Figure 3 in Attachment A).
- C. Connect a vacuum pump to the sample inlet port on the exterior of the vacuum box using a new piece of silicone tubing fitting. Open the valve on the Tedlar® bag inlet stem by turning the knob a single revolution counterclockwise.
- D. Operate the pump to purge air from the Tedlar® bag. Once the bag is empty, close the inlet valve on the Tedlar® bag by turning the knob clockwise until snug. Disconnect the vacuum pump from the sample inlet port.
- E. Connect the sample inlet port on the exterior of the vacuum box to the sample port on the source air stream, using a new piece of clean and unused Teflon® tubing to minimize potential VOC adsorption on tubing walls. Open the valve on the source air stream sample port.
- F. Connect the vacuum pump to the purge port on the exterior of the vacuum box using the quick-connect fitting (see Figure 5 in Attachment A). Operate the vacuum pump to draw vapor through the sample tubing, purging the tubing of ambient air:
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- H. To fill a Tedlar® bag with a vapor sample, connect the vacuum pump to the vacuum port on the vacuum box. Open the inlet valve on the Tedlar® bag. Close and seal the vacuum box. Turn on the vacuum pump. The vacuum pump will create a vacuum inside the vacuum box, inducing vapor to flow from the sample port to the Tedlar® bag. Monitor the Tedlar® bag through the window in the vacuum box.
- I. Operate the vacuum pump until the Tedlar® bag is approximately 80% full based on visual inspection (see Figure 2 in Attachment A). Turn off the vacuum pump, open the vacuum box, and close the inlet valve on the Tedlar® bag.
- J. Record the sample location, date, and time of sample collection on the appropriate field form or field logbook.
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ATTACHMENTS

Attachment A SKC Ltd., Application Guide for Using Sample Bags with the Vac-U-Chamber. SKC Publication 1302 Rev 0312

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Attachment A

SKC Application Guide for the Vac-U-Chamber